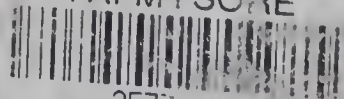


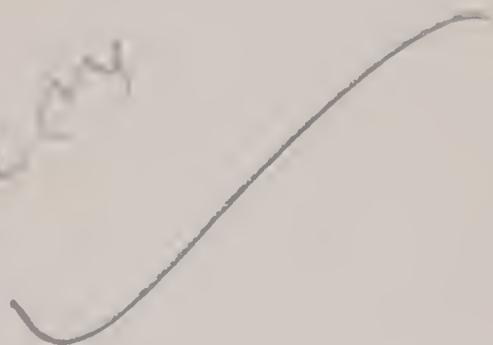
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Culture and mark.

May



THE CULTURE
AND MARKETING OF TEA

‘this healthful Herb’

J. OVINGTON, *Essay upon Tea*, 1699

The Culture and Marketing of Tea

by
C. R. HARLER

SECOND EDITION



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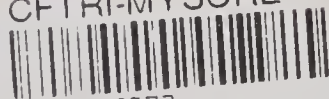
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Culture and mark

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To
A. W. H.

PREFACE

THE first edition of this book about the growing, the preparation and the marketing of tea was published in 1933, since when such changes have taken place in the tea industry that complete re-writing has been necessary.

The war and its aftermath have considerably changed the business aspect of supply and demand. Yet such changes may be regarded as superficial compared with those brought about by the findings of scientists studying tea in the various countries of production and in London. Over the past thirty years the work at the Experimental Stations in Assam, Ceylon, Java and Japan has produced detailed information on every aspect of tea growing and manufacture. Much of the experimental work has confirmed views already held or has given support to practices of many years standing, but in other directions the scientists have opened up entirely new lines of procedure.

I have freely used the information included in the Annual Reports, Conference Proceedings and other publications of the various Scientific Departments, fully realizing that some of the statements made therein should not be regarded as the finally considered opinion of the investigator. However, in the pages which follow, only such statements with which I am in full accord are included, so that any error of expression devolves upon myself.

My thanks are due to the Indian Tea Association for their assistance in producing this volume, and to the Oxford University Press for uniform help and courtesy in dealing with the publishing of the book.

C. R. HARLER

London

30th May, 1955

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PART I

THE TEA PLANT, TEA PRODUCTION,
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OF TEA

CHAPTER I

THE TEA PLANT

The habitat of the tea plant—The name of the tea plant—Varieties and agrotypes—The roots of the tea plant—The growth of the leaf—Flower and seed—Tea selection—The vegetative propagation of tea.

TEA is made from the young leaves and unopened leaf buds of the tea plant, *Camellia sinensis* (L.) O. Kuntze, a species which includes some very distinct varieties.

The use of an infusion of dried tea leaves as a beverage has its origin in antiquity. According to existing records, tea was first cultivated and the leaf prepared in China. It is possible however, that the tribes of the Shan States of Burma, China and Siam, led by that instinct which prompts even primitive peoples to make use of alkaloid-yielding plants, have taken tea in some form or other as long as the Chinese.

There are many ways of preparing the tea leaf but most tea is designated green or black, the former also being known as unfermented and the latter as fermented tea. The term 'fermentation' is incorrectly used in this connexion, since true fermentation does not take place in tea preparation. The Shan tribes steam and pickle the leaf, making what is known as leppet tea which is eaten as a vegetable.

Tea leaf is rich in the alkaloid caffeine which may constitute as much as 4 per cent of the dry matter in young leaf. It is also rich in bodies belonging to the chemical group known as polyphenols and these may constitute almost one-third of the dry matter in the younger leaves. In the preparation of black tea these substances are oxidized and then condensed to form bodies having tanning properties.

Tea is drunk primarily for the stimulus given by the caffeine, but before this has time to act, the warmth of the beverage is comforting. Drinkers of black tea have acquired a liking for the

taste of the brew and for the briskness, strength and body imparted to the liquor by the condensed polyphenols.

The Habitat of the Tea Plant

The home of the tea plant is in and about the fan-shaped area included by Upper Burma, south-east China and Annam, in Indo-China. There are two main axes of geographical distribution, one running west and east from Assam to China, along a line approximating to latitude 29° N. This axis passes through an area longitude 98° E. where the north-east tip of Burma runs into the Tibetan plateau. From this location the second axis of distribution starts and runs south-east through the Yun-nan province of China and down the Annamite chain of mountains to Cochin-China. It includes Laos and Tonking on the east and the Shan States of Burma and Siam on the west. The east-west axis extends over about 1,500 miles and the other over perhaps 1,200 miles.

A great part of the natural home of tea outlined above includes some of the populous provinces of China where tea culture has been a village industry for many centuries and it is not surprising that no wild tea has been found in this area. The search for wild tea in much of the rest of the triangle is complicated by the fact that hill tribes have for ages been on the move, cutting down and burning the natural jungle and taking plants, including tea, from one place to another.

In Assam, from about 1823 onwards, much tea has been discovered growing both in the plains and the hills, but it is not considered that the Brahmaputra valley is part of the home of tea because the plants were found in regular rows, suggesting village plantations, or in small patches not dispersed, near highways. The same applies to plants found in Manipur and in parts of Burma. Tea has not been found on the north bank of the Brahmaputra.

So far as the other axis of distribution is concerned, wild plants were found near Mengtze, just north of the Tonking border, in 1896 during a botanical survey of Yun-nan. Much tea is found in the jungle in Upper Siam but its wildness is often doubtful. However, a botanical survey of this area in 1922 found wild tea to the east of Pitsanloke and also in the coastal range to the east of Moulmein, bordering on Lower

Burma. These locations are about latitude 16° N. which was the farthest south that wild tea had been discovered at that time. Wild tea has since been found along the whole length of the Annamite chain from Tongking and Laos to Indo-China, which takes this axis as far as latitude 11° N.

It may be agreed that the habitat of the tea plant is about the area described, although that is not the end of the problem. There are three main races of tea, the China, the Assam and the Cambodian types. The most marked form of each of these types or races is to be found at the extremes of the fan-shaped area under discussion. The three races are so dissimilar that some botanists regard them as sub-species rather than varieties. Yet in all three areas there is evidence, sometimes marked, of hybridization by the other types.

The question which now arises is, what is the prototype or original plant, if there is one, giving rise to these three races. Is it the bush with small matt leaves of the China type, or the conical tree with large glossy leaves of the Assam type, or the small tree with long, narrow, turned-up leaves which take on a reddish tinge in the autumn, like the Cambodian type. Consideration of the distribution of the genus *Camellia*, to which tea belongs, throws some light on the subject.

The genus *Camellia* is naturally restricted to the highlands of south-east Asia, from Japan to Nepal. The most widespread species of the genus is the tea plant *Camellia sinensis* and the most widespread variety of tea is the *assamica*. Excluding tea, there are about fifteen species of *Camellia*, and at least half of them come within the Assam-Burma-west China belt which includes the area covered by the Assam variety and the large-leaved China variety.

It is possible, from geographical considerations and from points of similarity in the forms of the plants, to allow that the Assam and Cambodian types had one origin, and that they became different, in due course, by segregation. It is likely however, that the China type, so different in appearance and habit from the other two, had a separate origin, farther north. Yet the Assam and Cambodian plants are distinctly crossed with those of China. This hybridization may have happened when the northern flora of this part of the land mass of Asia was driven southwards during one of the glacial periods.

The Name of the Tea Plant

The binomial system of nomenclature of plants was established by the Swedish botanist Linnaeus. This gave each plant a double name consisting of two Latin words, the first being the name of the genus and the second of the species. The names either describe the plant in some way or are given in honour of a botanist. Thus the generic name of *Camellia* is derived from Kamel or Camellus, 1661-1706, a Moravian Jesuit who wrote on plants in Asia. The specific name *sinensis* indicates the connexion of the plant with China.

Plants of the same species differ in minor details whereas plants of the same genus, although bearing some resemblances, cannot be crossed, or if they are hybrids result. Within the species, only varietal differences occur.

In 1753 Linnaeus published his *Species Plantarum* and named all the plants then known. Two genera *Thea* and *Camellia* were recognized which enter into this discussion. At that time only one species of the former genus, viz. *Thea sinensis* the tea plant of China, and two of the latter, viz. *Camellia japonica* and *C. sasanqua*, were known.

In 1762 Linnaeus distinguished two varieties of tea, *Thea viridis* and *T. bohea*, the former being the plant thought to be used in the making of green tea and the latter of black tea. *Viridis* denotes greenness and *bohea* is derived from the name of a mountain range in the Fu-kien province of China where black tea is made. Later it was shown that green and black tea were made from the same plant which was then called *Thea bohea*. Confusion started from this time and increased as each botanist took up the subject. Almost a score of specific names have been given to the plant, and many more names to varieties, races and types. Different botanists have sometimes used the same name for different plants or different names for the same plant.

For many years now, botanists have combined the two genera *Thea* and *Camellia*, on account of the close relationship between the species included in the two. Although the genus *Thea* was recorded by Linnaeus before *Camellia* and therefore, according to international rules for naming plants, should take preference, the latter genus includes so many more species

than the former that it was retained and *Thea* discarded.

Under the *International Code of Botanical Nomenclature* the correct name for the tea plant thus becomes *Camellia sinensis* (L.) O. Kuntze provided that *Camellia japonica* L. (the well-known florist's camellia) and *Thea sinensis* L. are regarded as members of the same genus. The L. indicates that Linnaeus first published the epithet *sinensis* and O. Kuntze indicates that this botanist was the first to combine, in a publication, the generic name *Camellia* with the epithet *sinensis*.

The plants of the genus *Camellia* belong to the family *Theaceae* which includes some 240 species common in the tropics of Asia and America. At one time the family was called *Ternstroemiaceae* but this name has now been discarded. The tea plant is economically the most important member of the family.

There the matter rests at present. Although one name covers the whole tea population, there are at least four loosely defined groups within the species, differing markedly in form of plant and appearance of leaf. Scientific convention recognizes two varieties within the species, the China and the Assam, names which do not define geographical distribution for the Assam variety is found wild within the boundaries of China.

Varieties and Agrotypes

A glance at the bushes in practically any plot of tea in an estate shows a wide range of plants, both with regard to the frame, the shape, colour, texture and pose of the leaf, and the cropping potential.

The tea of commerce is a mixture of hybrids derived from China and India plants. The extreme form of the China plant is a bush which flowers early and plentifully. The leaves are small, smooth and dull-surfaced whilst the top of the leaf is often tinged with red. The extreme form of India plant, the Lushai-type, is a loosely branched tree sixty feet tall, with large shiny leaves, highly embossed between the veins and yellowish green when young. Between these two forms are intermediate varieties, all of which have been hybridized at some time or other and then formed into groups adapted to the particular habitat where they happen to be. Such groups are called ecotypes, but they are still able to cross freely with other

ecotypes of the same species. Thus a Burma type of plant can cross with a Lushai or a China bush, but the resultant hybrid may not do as well as the Burma plant when grown in the Burma habitat.

Several botanists have from time to time classified the ecotypes into varieties, sub-varieties and races. The classification of Cohen Stuart made in 1919 is as good as any. He defines four main groups, the first of which includes the true China plant, whilst the other three include the larger-leaved plants occurring in the countries bordering on the Tibetan plateau and in Indo-China.

Group 1. China. A bush with small leaves, $1\frac{1}{2}$ to $2\frac{1}{2}$ in. long, stiff, leathery, usually deeply coloured with 6 to 8 pairs of veins, not very prominent; leaves with no definite apex. This group occurs in east and south-east China and Japan.

Group 2. Big-leaved China. A tree up to 16 ft. high, leaves up to $5\frac{1}{2}$ in. long, 8 to 9 pairs of veins, no leaf apex. Occurs in Hu-peh, Sze-chuan and Yun-nan provinces of western China.

Group 3. Shan form. A tree 15 to 30 ft. high, light-coloured leaves up to $6\frac{1}{2}$ in. long, 10 pairs of veins, continuous apex. Occurs in Tongking, Laos, Upper Siam, Upper Burma (collectively known as the Shan lands) and possibly Assam.

Group 4. Lushai. A tree up to 60 ft. high, very large leaves 8 to 14 in. long, thin and flabby, 12 to 15 pairs of veins which are prominent and result in striking wrinkling of the leaf surface; a moderately long, sharply defined apex. Occurs in Manipur, Cachar, Lushai.

The tea grown in North-East India is of groups 3 and 4, and the planter recognizes the various forms and generally knows which suits his district best. The planter in Japan and Formosa, using the true China type, also recognizes many sub-groups which are referred to again later in the chapters dealing with those countries.

For the past twenty-five years, W. Whyte has been studying the tea plant in Assam and has evolved a classification based

on agrotypes. As defined above, an ecotype is a group of plants which have adapted themselves to certain surroundings, the unsuitable members of the original population having failed to survive. Whyte has taken the cultivated ecotypes, which are known as agrotypes, and arranged them in order according to an array of variants. Such a range of agrotypes is called a cline, which is a continuous graduation of differences in form.

Each step along the cline is given a number or a letter so that a type can be accurately and simply denoted by its so-called agrotype index. The agrotype index of an area of tea can be averaged and an idea of its capacity and properties assessed thereby. This conception of agrotypes and clines, however much the ultimate details may be modified from time to time, has put the subject of the classification of tea on to an intensely practical plane, has revealed the poor quality of much of the tea stand in North-East India, and shown the potentialities of selection based on certain agrotypes.

The agrotype index which has been evolved over the years in Assam to denote different types of tea, ranges from above plus 40 to below minus 130. These figures have no absolute significance and the range might well be from 1 to 100 or from 1 to 1,000 or from *a* to *z*. The agrotype index covering the four main types is as follows.

<i>Agrotype index</i>	<i>Agrotype</i>
above +40	China
+40 to -40	Burma
-40 to -130	Shan
below -130	Lushai

The type of bush best suited to Assam has an agrotype index about minus 60. Agrotype surveys in Assam have indicated that the stand ranges well over the Burma and Shan types with small percentages of the China types and in places a leaning towards the most negative Shan types.

The cline of agrotypes recently used in Assam depends on the leaf patina and pose. Four types are recognized:

- A. China, leaf surface matt
- B. Burma, leaves glossy, erect pose
- C. Shan, leaves glossy, intermediate pose
- D. Lushai, leaves glossy, dependent pose

The characters used in the above cline can be linked up with the morphology or internal structure of the leaf. Thus the clinal characters have a fundamental basis and depend on more than just the pose of the leaf on the stem, or the nature of the leaf surface. For example, if a section of the leaf stalk or petiole be examined under a microscope, it is found that phloem cells, which conduct food through the plant, steadily decrease in numbers from the China to the Lushai type. A relationship between the number of water conducting vessels in the petiole and the type has also been established. The number of calcium oxalate crystals in the phloem seen in a transverse section of the petiole, the so-called phloem index, can also be correlated with the agrotype index.

Field observations in Assam have shown that both the extreme types A and D are naturally poor yielders. Furthermore types B and C respond well to either sulphate of ammonia given at the rate of 400 lb. per acre (84 lb. N) or shade provided by *Albizzia stipulata* planted 40 by 40 ft. square. The A and D types give a poor response to both these treatments. The implications of these observations are clear, for if an area has an agrotype index leaning towards the Lushai or the China types, the response to sulphate of ammonia or to shade will be smaller than that shown by the median types.

It is certain that as the full significance of the agrotype index is realized in North-East India tea seed will be grown from plants chosen from median or middle types, with the avoidance of the A and D types. The effect of such discrimination will be considerable both with regard to the yield of the stand and the quality of the tea.

The Roots of the Tea Plant

When a tea seed germinates the shell cracks and the rootlet first appears as a white thread, and at the end of a year in the nursery the root may have descended a foot or more into the soil. After planting out in the field the roots extend and laterals grow, but whether they are mainly vertical, horizontal or intermediate depends on the habit of the particular plant. The rooting habit of leaf cuttings is just as much a clonal characteristic as are yield, type of leaf, resistance to disease and

so on. The bushes in a new clearing which die in a drought are often horizontal rooters.

Tea is a shallow-rooting plant, sensitive to the physical condition of the soil and only penetrating unkind soils with difficulty. The usual Assam type of soil is particularly kind to the tea bush. In Assam there are two major periods of root increment, one associated with summer and the other with winter conditions.

Most bushes maintain a definite tap root which may be three inches or so in diameter and 3 to 5 ft. deep. The lateral roots are limited in spread by the presence of neighbouring bushes. On the edge of a bank, the vertical roots may descend as much as 20 to 30 ft. but this never happens otherwise. In the *bheel* soils of Cachar, where a high water table is permanently present, none of the roots penetrate below this and the system extends no deeper than a foot or so.

The youngest roots, just behind the growing tip are white or cream in colour. These rootlets absorb water and foodstuffs in liquid form from the soil, passing them by way of the thicker, red roots, to the leaves for manufacture. The red roots have a corky layer which prevents water entering or leaving and these store surplus food, largely as starch. In Assam the starch reserves increase from the late spring to the winter season, and are at their lowest at the time of the first flush which grows partly at the expense of the starch reserves.

Most of the feeding roots are in the top soil where the foodstuffs are mainly located. The part of the rootlets just behind the tip is associated with soil fungi, probably in a mutually beneficial form of symbiosis. In Assam these fungi are not found on the roots of seedlings, which carry root hairs, but on older plants they cover the rootlets in a web and penetrate into the root tissue. It has been assumed that these fungi, known as mycorrhiza, supplement the work of the root hairs.

The lateral roots of the China bushes frequently throw up adventitious branches, but this habit is not usually shown by the Assam types.

The Growth of the Tea Leaf

The development of the tea shoot as may be observed by the planter in North-East India will first be described. The bush is

pruned in December and by the end of January leaf buds appear on the one-year wood. In February the buds begin to open and the leaves unfold. The first leaf is a very small, false one, oval in shape without serrations, and this is usually followed by a malformed leaf, partially serrated but often without an apex. The former is called the *janam* (Assamese—birth leaf) and the latter the *gol-pat* (Assamese—round leaf) or in Ceylon, the fish leaf. Then generally five normal leaves grow, sometimes more and sometimes less. These leaves are arranged round the stem in a spiral and five leaves encircle the stem twice so that the sixth leaf appears above the first. This leaf arrangement or phyllotaxis is described as the 2-5 system, the 5 referring to the number of leaves making up the system and the 2 the number of times the stem is encircled to complete the series.

In the full season a fresh leaf unwraps itself from the bud and unfolds rapidly each four to six days. Within the bud are smaller and smaller leaves awaiting their turn, crowded round the growing tip of the stem, and finally the *janams* which will in due course be exposed when the bud becomes *banjhi*. A bud which is about to turn *banjhi* is thin and is short compared with the leaf just unfolded.

After a period of rest the *banjhi* bud develops again, first with *janam* and *gol-pat* leaves then with a flush of about five leaves. *Banjhi* buds of this type may be referred to as resting buds, but other buds remain *banjhi* over a much longer period and these may be considered to be dormant buds, for they need an appropriate stimulus to make them grow again. The resting buds grow after plucking and the dormant buds after pruning. It will be understood that the rotation of pruning is related to the tendency of the bush to form dormant buds. In Assam a bush left unpruned for a year produces a large proportion of dormant buds by the middle of the second season.

A top-pruned bush in Assam produces about five flushes, as the growths between *banjhi* periods are termed, during the season. Over the first few days of the new flush, the growth is made partly at the expense of food reserves within the bush. Then for two or three months the leaves work to make food for the bush, after which period they act as stores for food reserves.

A close study of the phases of growth of the bush gives information of great interest. Thus it has been observed that

existing flushes of two orders (as second and third flush) may be growing simultaneously on different shoots of the same plant, but the initiation of more flushes of the lower order ceases when a new flush appears. Thus the start of the third flush prevents some laggard shoots from making more than one flush. Each successive flush of the more vigorous shoots means that other shoots will remain dormant.

As the season develops in Assam, the growth interval between flushes becomes shorter till about December, when the period of the last flush ends. In the spring a fresh start is made with an annual re-birth or climacteric, and the buds which may have become dormant during the previous year start to grow again. Without the stimulus of pruning many terminal buds, as stated earlier, appear to become dormant before the end of the season. Yet some of these buds are not inactive but produce rudimentary scale leaves or cataphyllary flushes, unnoticed by the casual observer.

When three flushes develop on a shoot, the leaves of the lowermost flush are discarded, and this holds whether the flushes are leafy ones or cataphyllary. Hence two scale-leaf flushes will denude a shoot of all its leaves so that it will eventually die. If a dormant bud develops neither leaf nor scale buds, the shoot retains its leaves indefinitely.

Plucking principles are based on the phasic growth of the plant. In Assam it has been found that a leading shoot rising from the frame after pruning gives its maximum yield when tipped at the top of its flush about the time it becomes dormant. Lower tipping may give a bigger crop for a year or so, but it fails in the long run. From this it will be gathered that a bush of fastigate form, that is of conical shape, will yield more than one with lateral growth since more of the shoots of the former will come into the plucking level in the optimum stage of development.

The first plucking of a bush stimulates the flushing of shoots on the lower leaf axils, but the general trend towards dormancy is the same whether a bush is plucked or not.

Inorganic manures, particularly sulphate of ammonia, break the dormancy of terminal buds and increase the leaf area and the fruit crop.

Mention is made elsewhere of the fact that pubescent or

hairy leaves produce quality teas in Assam. It is also observed that quality goes with both a high proportion of stem to leaf weight in the shoot, and high density of the wood in the leaf. Thus the best plants produce shoots with the most stem.

The Tea Flower and Seed

The tea flowers are globular on pendulous stalks, usually occurring singly or in pairs, but sometimes as many as five are grouped together. The flowers are white and fragrant and about $1\frac{1}{4}$ in. in diameter.

The calyx or outer case of the flower is leathery and glossy, consisting of five to seven sepals. The petals, equally five to seven, are egg-shaped and externally convex, fusing at their base with each other and with the stamens, and falling off with the stamens as a whole.

The stamens, which produce the pollen, are very numerous and are united at their base. The stigma, or receptive organ for pollen grains, is part of the stalk or style standing above the middle of the flower. The style is split for the top third of its length and sometimes down to the ovary. The ovary, containing ovules which become seeds after fertilization with pollen, is connected with the style of course and is three- or four-celled and coated with white hairs.

The fruit pod is hairless, about 1 in. in diameter and one- to four-lobed according as the seeds have set in one or more cells. There are one to three seeds in each cell and one to six seeds in each fruit. The seed is dark brown, about $\frac{1}{2}$ in. in diameter, almost smooth, spherical or mutually flattened.

Plants of the China type flower when about a year old and then produce seed about twelve months later. The Assam plant does not usually flower till it is two years old.

The production of flowers follows the phases of leaf growth. A flower bud is produced only in the axil of a leaf which is breaking from the resting period or from one which is producing a cataphyllary flush. In the latter case the flowers appear as a terminal cluster.

In Assam the sequence of seed is as follows. When the first flush ends its resting period and breaks into the second flush some time up to mid-April, flower buds form in the cataphyll or *janam* axils. These open about half-way through the third

flush, some time in August and are then pollinated, if at all. Similarly flower buds formed when the third flush breaks in July or August, or the fourth breaks in September, open to flower respectively during the fourth flush in November or the fifth in December. In spite of the difference in time of initiation, the pollinated flowers produce their seed all about the same time, in the following September. Thus from flowering to seed fall occupies at the most about twelve months. There is apparently little seed from flowers which originate after the fourth and fifth flushes.

The speed of germination of tea seed increases with the lateness of the seed fall, the last to fall having a short period of germination.

Tea flowers are largely self-sterile and seed from self-pollinated flowers have a lower germinating capacity and produce plants inferior in vigour to those from cross-pollinated seed. Only about 2 per cent of the tea flowers on a tree set to form seed, although the artificial transfer of pollen may raise the set to 14 per cent. Many plants are self-sterile and most of the Lushai type are in this category, although China plants are largely self-fertile. The set of fruits on the average seed garden tree ranges from nil to 40 per cent. Seed growers know that certain trees never bear seed, although they may be suppliers of pollen. One tree may be incompatible with another and fail to set after pollination, and to be absolutely sure of getting even 2 per cent of the flowers to set seed at least nine random trees are needed in a population.

In nature the pollen is carried from one flower to another by insects, and in Java it is considered that in this way wasps may take pollen over a range of 1 kilometre or 5 furlongs. This gives a rough idea as to the distance a seed garden should be isolated from other tea if cross-pollination by other strains is to be avoided.

Tea Selection

Although it is obvious to anyone who grows the tea plant that some bushes are better yielders than others, and although tea growers in Japan have realized for a century or more that the leaf from some bushes gives better quality tea than that from others, it is only during the past twenty-five years or so

that the problem of tea selection has been scientifically studied in India and Ceylon.

In 1875 plants were taken to Japan from India and used as a basis to produce a hybrid with China varieties, suited to making black tea. In 1887, again in Japan, the Yabukita strain was isolated from China bushes for making quality green tea. Many other strains have since been selected and they are usually propagated vegetatively. In Formosa more than fifty years ago various strains were recognized for different attributes and the good ones were used for propagation by layering.

In Assam, the pioneer planters early realized the superiority of the indigenous plant over the China varieties for use in Assam. The so-called wild tea found growing often in rows or clusters near Makum and Nazira in Upper Assam was the basis of the first selection, and from these plants what is known as *busti* or village seed was collected. In the nursery, the plants from this seed were selected and those of the China type discarded. In this way, what is known as the Assam indigenous plant was produced.

Planters soon observed that the light-leaved Assam plants were not so hardy as the dark-leaved with regard to drought resistance and die-back after pruning, although the light leaf produced tea of better quality. Later on planters in Cachar tried out the Lushai type of bush but found it a failure compared with the darker leaved Assam and Burma types.

From 1880 to the end of the century, Sir George Watt advised and assisted the Assam planters in selection and many good strains were chosen and grown in seed gardens. The name of the garden growing the seed is given to the strain and this is known as the *jat* of the tea. As knowledge spread the range of strains in use was narrowed down and in due course many different *jats* came in actual fact to be the same strain of bush. Selection was made wholly on appearance of the leaf and the form of the plant.

In a recent scientific survey of the tea seed gardens of North-East India it was found that about 70 per cent of the *jats* consisted mainly of plants of the Shan type, 20 per cent of the Burma type, whilst the balance were of the extreme Lushai or China types.

In Java, the intensive study of selection in the field was

taken up about 1910 and the seed of nineteen well-known Indian *jats* and three Java *jats* were grown in separate nurseries, the seedlings carefully selected and put out in twenty-two separate seed gardens isolated in the jungle. The best trees in each seed garden were in due course selected for leaf appearance, form of frame and freedom from disease, and the rest were cut back. The cut-back trees were allowed to grow three or four strong shoots which were then cut to 6 in. to take crown grafts of cuttings from the selected trees.

Although a magnificent even stand of selected trees and grafts was obtained in each of the twenty-two gardens, the seed produced therefrom gave plants showing little relationship between *jat*, as judged from appearance, and crop. Plants considered to be inferior, judged from appearance, often gave better yields than those assumed to be of good *jat*. Selection primarily from the appearance of the leaf is hence not satisfactory.

In 1930 it was shown in Java that a taster can recognize marked differences between teas made from leaf plucked from different bushes. This fact complicates the problem, for it indicates that the selection of the ideal bush must be based not only on yield but on quality potential.

In Assam, about 1935, the study of the quality of the tea made from leaf plucked from individual bushes was taken up, a task simplified by a miniature rolling machine invented by R. M. Pizey which deals with about 2 oz. of leaf. In this way it was shown that leaf from an individual bush which, judging from appearance looks the same as the rest, might produce a tea differing in value by as much as 1s. per pound above average. The bushes giving teas of such high quality were found to have abnormally hairy undersides to their first and second leaves. In some cases, individual bushes gave teas with a particular aroma, but this character could not be associated with any visual property of the leaf.

It was also shown in Assam that bushes with yellow-green shoots are associated with quality in the made tea. This light colour in the leaf may be a symptom of disease or it may be due to a shortage of chlorophyll, the green colouring matter in the leaf, bringing about a condition known as chlorosis, a state which is inherited and passed on.

However, the importance of the yellow colour is greatly reduced when hairy-leaved plants are dealt with. In fact the realization of the positive association between hair on the leaf and quality has proved to be a major factor in the problem of tea selection, for it is independent of leaf colour, leaf shape and other obvious properties. Any type of plant can give quality provided the leaf is hairy.

As indicated earlier, the Shan and Burma types of tea do best in North-East India, and in selecting plants for breeding purposes, high-yielding bushes of these types should be chosen. The form of the plant should be conical or fastigiate, a property which makes for the delivery of the greatest number of shoots to the plucking surface. The leaves should be hairy. Unfortunately hairy leaves are often associated with an absence of leading shoots and a development of laterals. However, pubescence or hairiness of the leaf, as a criterion in selection has a value beyond that of quality, for it is positively related to yield under shade and tends to a more satisfactory balance between quality and yield than is possible by other methods of selection for quality.

At present in Assam many *jats* of seed give only a small proportion of pubescent plants, and although much is constantly being done to de-rogue seed gardens of undesirable trees, up till recently the overwhelming importance of the pubescent condition was not fully realized.

The next question is, if a seed garden is made up of hairy or pubescent plants, will the seed from these plants also produce hairy-leaved plants? Breeding experience shows that the glabrous or smooth or hairless condition in the tea plant is dominant to the pubescent or hairy condition. Hence it can be said that a pubescent plant is lacking in glabrous qualities and must produce pubescent-leaved plants when crossed with another pubescent plant.

Brief mention of some points connected with genetics, the science which deals with heredity, is here desirable. Within the ultimate cells of plants and animals are microscopic bodies called chromosomes, which are thread-like in shape and along their length contain the genes or units of inherited material. The cells of the tea plant contain thirty chromosomes, each with many genes which decide the colour, shape and habit

of the various parts of the bush. When a cell within a plant or animal divides, it produces two cells with the same number of chromosomes and same distribution of genes. On this account a leaf cutting or graft taken from a tea bush produces a plant in every way identical with the parent.

When a plant or animal reproduces itself sexually, each parent provides some of the genes or inherited qualities. Thus when a tea flower is fertilized, the genes from the two parents are, in effect, shuffled and dealt, so that the progeny may have any combination of its parents' qualities.

In the chromosomes some of the genes may occur in pairs, having related qualities, such as tall and dwarf, green and yellow, glabrous and pubescent, one of the qualities being dominant and the other recessive. It is common for two plants to look alike, but they may have different genes in the background of their make-up. If such plants are interbred, the progeny may not all look the same as the parents. It is common experience that, from a seed garden in which all the trees appear to be good Assam *jat*, the seed produces some bushes not true to *jat* or some which may even show the China strain. The undesirable genes of these off-*jat* plants were recessive in their parents, but have had a chance to come to the fore in the shuffle and deal of fertilization.

If a glabrous (hairless) tea plant is crossed with a pubescent (hairy) one, the progeny will be all glabrous, but they will all have the recessive pubescent gene in the background. In the next generation the shuffle will produce some plants with no glabrous genes and these plants will be pubescent. Hence, bred with their like, pubescent tea plants will produce pubescent progeny.

The fact that many other qualities in the tea leaf occur with pubescence, such as high density of xylem cells and low density of the phloem cells, suggests that all these properties are linked within the chromosomes and move together in the general shuffle, thus tending to be passed on in association from generation to generation.

The Vegetative Propagation of Tea

The hazards of propagation by seed from cross-fertilized plants have long been realized in agriculture, as has the value

of vegetative propagation. The scope of the latter is illustrated by the Cox's Orange Pippin apple, of which more than 6 million trees are grown. Every one of these trees is of the same clone, and came directly, or from a cutting taken from a tree grown from a cutting, emanating originally from one tree at Colbourne, near Slough, Bucks. When grown under similar conditions every such cutting produces apples like the original. If however a tree is grown from a Cox's apple pip, the fruit may have no resemblance to the original apple and may well be unsaleable.

In the same way a tea leaf cutting or graft grows a bush identical with the parent, but if allowed to produce seed by cross-fertilizing with another plant the progeny may or may not be very different from the parents.

These risks were known to the Japanese many years ago and vegetative propagation was recorded there in 1887. In Formosa tea plants have long been propagated by layers and marcots taken from good bushes. In 1914 vegetative propagation by woody cuttings was tentatively tried in Assam but it was not till about 1930 that the problem was seriously taken up. It was found that the most suitable type of cutting consists of a leaf and a dormant axil bud with about 1 in. or so of the stem below the leaf. All cuttings from one bush, whether of the first or subsequent generations, form what is called a clone. All members of a clone are of the same genetic constitution and look the same, whilst their quality and cropping capacity are the same as the parent or mother bush from which they originally descended, provided the cultural treatment is the same.

In Assam the bush selected to provide cuttings is given a cut-across prune in October and then allowed to grow. In the following April or May the young shoots are taken and used as cuttings. All leaves on the shoot may be used except the soft, immature first and second leaves at the top. If the axil bud is in an advanced stage of growth it should be nipped out. The green wood at the top of the shoot calluses better than red wood lower down, but is more susceptible to adverse moisture conditions and to die-back after the cuttings are planted.

A second lot of cuttings may be taken from the same bush in September/October. Each selected bush may give up to 600 leaf cuttings in a year under conditions in Assam.

A plant which is to provide cuttings should be treated with a manure mixture at the level of N/P/K=40/80/80 lb. per acre in the autumn. The soil of the nursery which is to take the cuttings must be shaded for about a month before their insertion and a special technique in respect of this shade has been worked out. The stalk of the cutting calluses in two weeks, the initial roots appear in six to eight weeks, the root is well grown in twelve to sixteen weeks, and the shoot is formed in sixteen to twenty weeks. The use of growth-promoting substances, like Hormone A, have no significant effect on cuttings taken at the right time, but may do good on cuttings taken out of season.

A technique has also been worked out in Ceylon, and the use of cuttings for extensions in estates is advocated there. Much valuable evidence has been collected and one experience, illustrating the complexity of selection, may be instanced. A few years ago Blister blight, *Exobasidium vexans*, appeared in the Island and a selection of plants showing natural resistance to this blight was made, irrespective of other characters. Of twenty-three clones thus selected, five were discarded owing to poor rooting and twelve were rejected in the field owing to poor growth. Of the remaining six, none were vigorous growers and it was seen that other clones, selected for vigour, gave more yield than the blight-resistant clones, in spite of a considerable amount of Blister blight.

Having worked out the method of vegetative propagation, the problem then is how to seek out the super tea plant, growing with vigour, having the correct form and producing a large yield of high quality tea. In India the following procedure was suggested in 1950. An area of about 14 acres of fine, proven tea is taken for a start, comprising about 40,000 bushes. This area is cut across in October and the 200 finest-looking bushes selected. They are chosen for vigour, density and uniformity of yielding wood, diameter of frame, size of flush and appearance of leaf. The 200 bushes are allowed to grow up till the following April or May, when leaf cuttings are taken from each bush and planted in three different types of soil.

After about six months, the poor rooting clones are noted and discarded, and this may leave fifty bushes for further consideration.

These fifty bushes are then plucked the following year and the

leaf manufactured separately. In this way it may be found that three to five bushes give tea preferable to the average and one is perhaps definitely better. This one may be used for breeding.

The selected bush can be used for vegetative propagation or it can be crossed with another clone or clones, similarly selected, to give seed. Such plants are called generative clones, and until the seed so produced has been grown and the plants therefrom judged the experiment is not complete.

In Assam, although much work with cuttings on tea estates has been carried out, the long-term breeding principle is the production of first-generation seed from two or more vegetatively propagated clones which will be allowed to grow into seed-bearers. In the meantime, so much information has been made available on the subject of selection and the behaviour of the various agrotypes that a marked improvement in the tea stand now being planted will inevitably follow.

CHAPTER II

CLIMATE AND THE PRODUCTION OF TEA

The distribution of tea areas—The effect of climate on tea growth—The monsoon—The climates of Assam and Southern China—Japan, Formosa, Ceylon and South India—The East Indies and the Kenya Highlands—Ranchi, Poti and Chipinga.

BEFORE opening up new tea areas three primary factors must be considered, the first of which is the suitability of the climate. The other two are the suitability of the soil and sufficient labour to deal with the crop.

Soil problems are discussed in the next chapter. With regard to labour requirements, these are high on tea estates and in the heaviest yielding areas of Assam two workers per acre are needed in the plucking and manufacturing season. Further reference is made to labour in a later chapter dealing with mechanization in the tea industry.

The question of the economics of tea growing arises in countries not ideally suited for the crop, like Georgia, Turkey, Iran and Northern India. In such cases the commodity is consumed locally and it is doubtful whether such producers could compete in the open market with tea from Assam, Ceylon and Indonesia.

In the present chapter the climates of various tea areas are described. Further details on the same subject will be found in other chapters dealing with individual countries.

The Distribution of Tea Areas

Tea will grow almost anywhere where it is wet and warm but a tea estate run on modern lines, with amenities given to a settled labour force, can only thrive where the climate is such that big yields are possible. Of recent years it has become

evident that outstanding quality and flavour may not suffice to compensate for small yields.

In Ceylon it has been reckoned that 1 acre of tea in full leaf will draw from the soil, during normal fine weather, about 10 tons of water a day, which is equivalent to about 0.1 in. of rain. Of the rain that falls on the soil some percolates through and is eventually lost as drainage, some may be lost by surface run-off and some by evaporation from the soil surface. Thus, if the rainfall is evenly distributed so that little is lost by drainage or run-off, and if the surface evaporation is reduced to a minimum, it will be seen that a considerable quantity of rainfall is still needed to provide for leaf transpiration. It is generally assumed that a minimum of 45 in. rainfall per annum is necessary to grow tea, although this may not suffice if temperatures are high. This aspect of the subject is again dealt with in connexion with the climates of Ranchi, Bihar and Chipinga, Southern Rhodesia.

Tea is grown over a wide range of latitudes. The most northerly is in Georgia, situated in the Trans-Caucasian province of the U.S.S.R. The tea districts are near the Black Sea about latitude 42° N. where the winter is long and severe, and 10° frost is sometimes registered and snow is common. Nearby is Rize, the tea area in Turkey.

The most southerly tea area used to be at Stanger on the Natal coast 29° S. about forty miles north of Durban. Recently this tea was replaced by sugar, so that the most southerly areas now are in Corrientes, Argentina, near Santos, Brazil, and in Chili. The tea planted in the Melsetter district of Southern Rhodesia is only about 20° S. and hence not as far south as the areas in South America which extend to 27° S.

Between these two extremes tea is grown in many countries, the chief areas in order of size of crop produced at present being the Yang-tsi Valley and Southeast China, North-East India, Ceylon, South India, Japan, Indonesia and Formosa. All the other countries in South-East Asia produce tea, including Siam and Burma (pickled tea), Indo-China and Malaya. The culture of tea in New Guinea and North Queensland is under consideration.

In North India, tea is grown in Ranchi, Dehra Dun and the Kangra Valley in the Himalayas. Continuing along this line,

tea has been long established near the Caspian in Iran, and near Batum in Georgia, U.S.S.R. Tea is being grown in Turkey on the Black Sea coast, adjacent to Batum.

Tea for local consumption is grown in Fiji, the Azores and Mauritius, the last having also sent its product for sale in London.

In Eastern Africa, tea is grown in the equatorial area in Kenya, Uganda, northern Tanganyika and the Belgian Congo. It is grown in the Nyasa tea belt, further south, which includes southern Tanganyika, south Nyasaland and the adjacent area in Portuguese East Africa. Tea is grown in the eastern area of Southern Rhodesia. A start has been made in the Cameroons in West Africa.

Tea can be grown in the southern states of the U.S.A. and from 1890 to 1915 an experimental station was worked in South Carolina. The tea grew well but labour costs made it an uneconomic crop. Tea is grown in Mexico and Guatemala, in Central America. It is grown in Colombia, Bolivia and Peru, and in the last country 2,600 acres are in production. Well over a century ago, tea was grown near St. Sebastian in Brazil and now, near Santos, over 5,000 acres are planted producing $1\frac{1}{2}$ million lb. tea, much of which is exported. In the Argentine, in the Corrientes and Misiones territories nearly 8,000 acres are put out, producing $2\frac{1}{2}$ million lb. tea at present.

The Effect of Climate on Tea Growth

Climate is the deciding factor as to which variety of tea can be grown to the best advantage. Climate affects crop distribution and the periods of quality and flavour. It influences the time of maximum seed fall.

As indicated earlier, there are two main varieties of tea, the China and the Assam. The small-leaved China bush is more hardy than the large-leaved Assam plant, and it is grown all over the China tea areas and in Japan and Formosa. The Assam plant would certainly grow well in southern China, and it is being grown in Formosa successfully. In Japan, where green tea is by far the main product, the China variety is grown, although for the manufacture of black tea an Assam-China hybrid is used. The climate of Japan, like that of the

Yang-tsi Valley of northern China, is too severe for the more delicate types of the Assam plant.

In the early days of the industry, China plants were brought to Java and Assam, but only a small percentage of the present stand is China. The extreme type of China bush grows with difficulty in the plains of Assam, although the bigger leaved China varieties and the so-called China-hybrid thrive, but the average yield and quality are markedly below the standard reached by the average Assam plant.

In the Darjeeling area of the Himalayas, which in the spring produces very fine, flavoury tea, the bushes are China-hybrid, and the Assam type, although it does well there, fails to produce the full hill flavour. On the other hand, hybrid bushes from Darjeeling grown in the plains of Assam also fail to reproduce the full hill flavour. It may thus be concluded that Darjeeling teas owe their character partly to the type of bush and partly to the climate.

The China-hybrid is common in Ceylon and Mauritius, and plants were taken from these countries to Nyasaland many years ago. The Assam plant certainly grows well in Ceylon, although whether the mixed Assam type would maintain the quality and flavour for which Ceylon teas are noted is doubtful. In South India, where the climate closely resembles Ceylon, all the Assam types do well and are in general use, but South India teas have not the quality of those of Ceylon. The China-hybrid tea in Nyasaland is now looked upon as a handicap and new openings are with the Assam and Burma types. Similarly in the rest of Eastern Africa, from Southern Rhodesia to Kenya, the large-leaved plant is favoured.

In Ranchi, Dehra Dun and the Kangra Valley, the original China type of plant first imported is still grown and indeed it is doubtful whether the Assam plant would thrive in these places. In Iran, Georgia and Turkey, none other but the China plant will do.

The natural home of the tea plant is the monsoon lands of South-East Asia, where the cool or cold weather is fairly dry with a marked temperature fall. In April and May, the temperature rises and there is some rain. Over this period the spring growth of quality tea is harvested. In June the monsoon breaks, and humidity rises, so that leaf growth is rapid and

quality falls off. In October the rains tail off, the humidity falls and autumn teas with quality are made. In the cool, dry season the leaf buds become dormant and the bush ceases to flush or flushes slowly till the spring rise in temperature.

In China, the whole of the first flush is plucked and a big early crop is thereby made. In Assam, the first flush is allowed to grow freely before it is tipped at 6 to 8 in. above the pruning, about the time the shoots begin to rest or turn *banji*. Most of this flush is thus left on the bush and the second flush is the beginning of the heavy cropping period. During the early days in Assam about 1850, plucking procedure as in China was followed with results resembling those in China. The different crop distribution given by the two methods is shown below:

CROP DISTRIBUTION IN CHINA AND ASSAM

	<i>China</i>	<i>Early days in Assam</i>	<i>Present-day in Assam</i>
	%	%	%
Spring teas . . .	53	44	25
Summer or rains teas . . .	31	35	60
Autumnal teas . . .	16	22	15

It might be thought that since close plucking in the early months gives large spring crops, with quality and flavour, such treatment should have been retained in North-East India. It must however be noted that in the pioneer days in Assam the crop was under 300 lb. tea per acre, partly owing to the close early plucking, against a common yield of 1,500 lb. today.

Where there is no marked change in temperature throughout the year, the tea plant has no dormant season and the crop is harvested all the year through, albeit perhaps at an uneven rate. The next table shows the temperature range in a number of areas together with the cropping period. It will be observed that in Nuwara Eliya, Ceylon, the mean monthly temperatures through the year are about the same as those during the cold weather dormant season in Assam.

In Nyasaland and Southern Rhodesia the temperature difference between January and July is insufficient to shut up the bush, although the fall combined with rain shortage reduces the outturns in July and August to about 1 per cent of the total for the year.

TEMPERATURE RANGE AND CROPPING SEASON				
<i>Location and altitude</i>	<i>Latitude</i>	<i>Mean temp.</i>		<i>Cropping season months</i>
		<i>January</i> °F.	<i>July</i> °F.	
Poti, U.S.S.R. (sea-level)	42° N.	44	75	6
Hankow, China (160 ft.) .	31° N.	40	84	6-7
Tocklai, Assam (290 ft.) .	27° N.	60	83	8-9
Kandy, Ceylon (1,654 ft.) .	7° N.	73	75	12
Nuwara Eliya, Ceylon (6,188 ft.)	7° N.	57	59	12
Kericho, Kenya (6,000 ft.) .	0	65	62	12
Bandoeng, Java (2,000 ft.) .	6° S.	75	77	12
Cholo, Nyasaland (3,500 ft.) .	16° S.	73	62	12
Chipinga, S. Rhodesia (2,500 ft.)	21° S.	73	59	12

It might be considered that shortage of soil moisture resulting from lack of rain and not difference in temperature is the factor which causes the bush to winter and cease flushing in some countries. In the Poti area the closed season is the wetter one, although much of the precipitation may be as snow. In Assam the irrigation of tea still fails to make it flush in the cool season, whilst the tea planted in Cachar on peat soils, which maintain a water table a foot or two below the surface throughout the dry weather, still becomes dormant in the cool season. At New Year's Gift, Chipinga, Southern Rhodesia where most of the estate is irrigated, the crop distribution curve is the same as that on nearby estates which are not irrigated.

In Assam and China the leaf has quality and flavour in the spring and autumn, when the atmosphere is dry. Similarly in Ceylon, the best quality teas are made in the dry months. In countries like Java and Kenya, where the seasons are not marked and growth is steady throughout the year, there is no definite quality period. It would appear that quality in tea goes with xeromorphic leaf growth, that is a form of growth designed to cope with a dry atmosphere and water shortage. This agrees with the observation that plants with pubescent (hairy) leaves give quality teas, for such plants are designed by nature to withstand dry conditions.

The table below shows the monthly crop distribution in Upper Assam where in many respects the climate is ideal for tea; in South India where only the areas served by the fierce south-west monsoon are dealt with; in Java and the Kericho district of Kenya where an equable climate throughout the

year is experienced; and in Cholo, Nyasaland where moderate rainfall for five to six months is recorded whilst for three months the weather is hot and very dry.

CROP DISTRIBUTION IN TEA COUNTRIES

	<i>Upper Assam</i>	<i>South India</i>	<i>Kericho, Kenya</i>	<i>Java</i>	<i>Cholo, Nyasaland</i>
	%	%	%	%	%
January .	—	4	9	9	15
February .	—	5	8	8	16
March .	—	8	9	8	16
April .	2	14	9	8	13
May .	4	12	7	9	7
June .	14	9	7	7	3
July .	16	5	8	7	1
August .	18	6	8	7	1
September .	18	10	8	9	4
October .	18	12	9	10	5
November .	10	8	9	9	6
December .	—	7	9	9	13

The climate has an effect on the tea tree as a seed bearer. As described earlier, the setting of the seed depends on the phasic growth of the leaf and accordingly in Assam the seed matures mainly at the end of the season, from September to early November. In Ceylon, South India and Java, where the phases of leaf growth are more evenly distributed over the year, the seed can be gathered monthly. In Ceylon about 10 per cent of the seed crop comes in January, nearly two-thirds between May and September and about 5 per cent in each of the other months. It is generally considered that Assam seed is preferable to that grown nearer the equator, and in Africa the seed of Nyasaland, which matures from February to April, is thought to be better than that grown in equatorial Africa.

Certain minor aspects of the effect of climate on tea growth may be mentioned here. Thus the effect of frost, hail and lightning are all hazards which have to be met from time to time.

When frost occurs, as it does in the high-grown districts of South India, the flush of the Assam type of bush is usually

blackened and killed if the sun reaches the affected area early in the morning before the leaf has had time to warm up. The damage usually occurs in ravines, where the cold air infiltrates, but not on ridges or gentle slopes. Tea growing under trees is not usually affected, because of the shade.

In Assam, tea is frequently damaged by hail in the spring up till about mid-May, and many estates insure against this event. Mature top-pruned and unpruned tea suffer most in loss of crop, but cut-back and young tea can suffer more lasting damage.

Lightning frequently strikes small areas of tea and kills the bushes, the roots of which are then very liable to root disease, whilst at the same time there appears to be an upset in the soil micro-flora. After lightning the dead bushes should be uprooted and the area planted with a leguminous crop. Tea may be replanted after about a year.

In the previous chapter the production of ecotypes in different climatic and geographical areas was briefly mentioned. When the hybrid swarm of plants which a sample of commercial tea seed represents is grown in an area under climatic conditions different from those of the seed garden, some of the seedlings may fail under the new conditions, and the make-up of the new stand will be different from that of the stand from which the seed came. A new ecotype has been formed.

The Monsoon

In order to appreciate the seasonal changes in most of the tea countries, some knowledge of the monsoon is necessary. This phenomenon dominates the climates of India, Indo-China and China, whilst it profoundly affects those of Japan, Formosa, Ceylon and South India. The African tea countries and the tea areas on the Black Sea come also under its influence. Indonesia is the only considerable tea area not affected by the monsoon changes caused by air currents over the Tibetan plateau.

Over a great part of the globe certain air movements prevail for most of the year. There is an air drift to the thermic equator, moving from the north-east and south-east, and these currents are known as the trade winds. They are moist and bring rainfall to the tropics.

In the north temperate zone the general air flow is from the south-west, whilst in the south temperate zone it is from the north-west or west. These two sets of winds are the anti-trades and they are moist and mild when they blow off the sea. The British Isles are situated in the track of the south-west anti-trades.

The regions between the trade winds and the anti-trades are belts of calms and scanty rainfall, and here are located the arid regions of the world. In the northern hemisphere these include the Sahara desert, Egypt, the Arabian desert, Iran and the Thar desert of North-West India. But for the monsoon, the rest of northern India and southern China would be arid or semi-arid regions.

The simple system of air currents just described is disturbed over the land mass of Asia by the air movements created by the Central Asiatic plateau. This area includes Tibet and Mongolia lying approximately between latitudes 30° and 50° N.

During the northern winter, central Asia is exceedingly cold and becomes a region of high atmospheric pressure. The anti-cyclone thus formed causes air to flow in all directions away from the plateau to the coast of Asia, from Siberia to Arabia, a gigantic arc which includes Japan, China, Indo-China and India. Coming from the desert this air is dry and accordingly China and North-East India experience their dry, cold weather at this time. Before it reaches Japan, Formosa, South India and Ceylon the wind crosses the sea and arrives wet and cold in Japan, wet and cool in the other countries. This air drift brings the so-called north-east monsoon rains to the Ouva district of Ceylon and the Madras side of India, where it is active from October to January.

During the northern winter the normal trade winds are in action south of the equator and impinge on the east coast of Africa bringing rain to the stretch from the equator to Durban. Over this period the tea lands of Southern Rhodesia, Nyasaland, Mozambique and southern Tanganyika experience their annual wet period from November to March.

The northern anti-trade drift is at this time moving across the Black Sea to the Caucasus, bringing rain and snow to the tea districts there.

As the summer advances in the northern hemisphere the

Central Asiatic plateau becomes exceedingly hot and gradually changes from an area of high to one of low pressure. As this change develops the outward air flow, blowing across India and China, is first weakened, then extinguished till finally the direction of the air movement is completely reversed. The air drift is then from all points of the compass towards Central Asia. Coming across the warm Pacific and Indian Oceans the wind is laden with moisture and so the wet monsoon arrives.

Not only are China and North-East India affected by the monsoon, but Japan, Formosa, the western side of Ceylon and the Malabar coast of South India receive heavy rains from this, the south-west monsoon. The Ouva district, on the eastern side of Ceylon, and the Madras side of India do not receive much rain from this monsoon because the precipitation has taken place on the Western Ghats and on the Ceylon mountains facing west.

The east coast of Africa, where the thermic equator has now moved north with the northern summer, is also affected by the intake of air into Central Asia. As a result, the trade winds blowing to the coast are weakened and the rainfall reduced so that much of tropical Eastern Africa is arid in the northern summer and the air flow is off the land towards India. The wet monsoon reaches Bombay from due west, the wind having moved from Eastern Africa and gathered its moisture whilst crossing the Arabian Sea.

In the Black Sea the attraction from Central Asia results in an air drift towards the east in the summer months, bringing rain to the Caucasus.

The Climates of Assam and Southern China

Some description will now be given of the climate in the natural habitat of the tea plant and the two main areas of tea production, North-East India and Southern China. Then the climates of the tea countries lying round the mass of Asia will be dealt with, Japan, Formosa, Ceylon and South India, followed by data regarding the tea area of Java, which is outside the monsoon influence, and of the Kenya Highlands, which are only partially affected by the monsoon.

Three extreme tea climates will finally be described, first that in Ranchi, Bihar then that in Georgia, U.S.S.R. ending

with data referring to New Year's Gift Estate in Southern Rhodesia.

The first table gives the average monthly rainfall and temperatures for Tocklai, Middle Assam. This district is not actually within the natural tea tract although tea is found nearby, but this is generally considered to be the remains of village plantations. The Assam or Brahmaputra Valley is perhaps the finest tea district in the world, partly on account of its climate.

The climates of the other tea districts of North-East India resemble that of Tocklai, some being more and others less ideally suited to tea planting.

CLIMATE OF TOCKLAI, ASSAM LAT. 27° N. ALT. 300 FEET

	<i>Rainfall</i> in.	<i>Average temperature</i>	
		max. $^{\circ}$ F.	min. $^{\circ}$ F.
January . . .	0.9	70	50
February . . .	1.3	73	53
March . . .	3.5	79	60
April . . .	7.7	83	67
May . . .	10.6	86	72
June . . .	12.9	89	76
July . . .	15.1	90	78
August . . .	13.1	89	78
September . . .	10.8	88	76
October . . .	4.5	85	71
November . . .	1.1	78	60
December . . .	0.4	72	51
Total	81.9 in.		

The next table shows the monthly rainfall and temperature of Canton, indicative of conditions in South-East China, and in Hankow, the tea centre in the Yang-tsi Valley. The latitude of Canton is 23° N. about level with Calcutta, whilst that of Hankow is 31° N. which may be compared with Doom Dooma, Assam 28° N.

The climate of Canton compares favourably with that in the Assam Valley, and the Assam plant would certainly grow well there. At Hankow which is 500 miles from the sea, the climate

is more severe and is unsuited to the Assam type of bush.

Winter in Canton resembles the English summer, but in the Yang-tsi Valley winter resembles that in England, although it is much shorter. South-East China, ridged more or less at right angles to the wet monsoon current, receives more rain than the plateau to the south-west of China. Thus the rainfall in Szechuan averages about 40 inches, Yun-nan 38 inches and Hu-peh 44 inches. These three provinces are considered to be the natural home of the big-leaved China tea plant.

CLIMATES OF CANTON 23° N. SEA-LEVEL AND HANKOW 31° N.
ALT. 400 FT.

	Canton			Hankow		
	Rainfall ins.	Average max. °F.	temp. min. °F.	Rainfall in.	Average max. °F.	temp. min. °F.
January .	1·4	65	54	2·1	47	33
February .	3·5	62	53	1·1	49	37
March .	7·0	68	59	2·8	58	44
April .	8·3	77	68	4·8	69	55
May .	10·9	84	75	5·0	80	64
June .	9·9	86	78	7·0	86	72
July .	11·0	88	80	8·6	90	77
August .	9·7	89	80	4·6	92	78
September	5·7	88	76	2·2	83	66
October .	3·5	83	73	3·9	73	59
November	1·0	75	64	1·1	61	47
December	1·0	69	57	0·6	50	37
Total	72·9 in.			43·8 in.		

The Climate of Japan, Formosa, Ceylon and South India

These four countries cover a wide range of latitude and climate. In Japan and Formosa as in China, there is a close season when the bush ceases to flush. In Ceylon and South India tea is made all the year round, although not at a steady rate.

The first table shows the monthly average rainfall and temperatures of the tea districts in Japan and Formosa. In both countries the China type is grown although the Assam bush does well in Formosa.

CLIMATES OF KANAYA, JAPAN, 35° N. AND HAICHIN, FORMOSA, 25° N.

CLIMATES OF KANAYA, JAPAN, 35° N. AND 135° E.						
	Kanaya			Haichin		
	Rainfall	Average	temp.	Rainfall	Average	temp.
	in.	max. °F.	min. °F.	in.	max. °F.	min. °F.
January .	2·8	48	34	3·7	66	51
February .	5·5	51	35	7·8	64	51
March .	7·5	56	38	9·5	66	55
April .	11·0	65	49	10·3	73	63
May .	9·0	71	54	13·4	82	68
June .	11·0	75	62	14·8	85	73
July .	8·2	82	70	5·9	90	75
August .	12·3	85	71	10·4	90	74
September	15·2	79	66	9·1	86	71
October .	7·8	71	56	4·0	82	65
November	7·1	63	48	2·5	77	60
December	3·0	53	36	3·9	70	55
Total 100·4 in.			Total 95·3 in.			

In Japan the summer temperatures are lower than those in the Yang-tsi Valley of China, whilst the winter temperatures are about the same in both places. Japan produces mainly green teas for the production of which the China bush is considered preferable to the Assam type. The tea crop in Japan averages 1,400 lb. per acre and the best areas give well over 3,000 lb. These figures are much higher than those realized in China, the bigger crop in Japan being due to better cultural methods.

In Formosa a semi-fermented tea called Oolong is made for which the China bush is grown. Although attempts are being made to modernize the industry, the outturn is still only about 250 lb. tea per acre. As far as the climate is concerned, Formosa like South-East China is suited to the growth of the Assam type of bush.

The next table shows the rainfall in four districts, two in Ceylon and two in South India. The figures for Nawalapitiya are not typical of a great area in the Ceylon tea districts, but illustrate how in places on the western side of the island the south-west monsoon can drench the countryside. Nawalapitiya stands at about 4,000 ft., the optimum altitude for rainfall. The

other Ceylon station shown, Badulla, is in the Ouvah district served mainly by the gentler north-east monsoon.

The two districts taken in South India are the Anamallais, a district standing at about 3,500 ft. in the Cardamom Hills just south of the Palghat gap, and the Nilgiris. The Nilgiri plateau stands north of the Palghat gap where the Western and Eastern Ghats meet, to form a land mass rising to an altitude of 8,000 ft. The Western Ghats take the brunt of the south-west monsoon rain and leave little for the Nilgiris which are however served by the north-east monsoon.

RAINFALL IN CEYLON AND SOUTH INDIA					
		<i>Nawalapitiya</i>	<i>Badulla</i>	<i>Anamallais</i>	<i>Nilgiris</i>
		<i>in.</i>	<i>in.</i>	<i>in.</i>	<i>in.</i>
January	.	8.2	9.7	0.4	2.4
February	.	3.7	3.0	0.1	2.3
March	.	5.1	4.3	0.2	1.9
April	.	7.9	7.5	3.5	4.1
May	.	13.8	4.5	4.0	6.0
June	.	65.8	2.3	28.6	4.1
July	.	38.5	2.0	83.2	4.7
August	.	39.6	3.2	23.7	4.3
September	.	40.7	3.4	17.3	6.6
October	.	24.6	9.9	8.2	14.4
November	.	16.4	10.5	3.4	10.2
December	.	6.6	12.4	0.3	4.3
Total		270.9 in.	72.7 in.	172.9 in.	65.3 in.

It will be seen that both Nawalapitiya and Badulla, in Ceylon, receive precipitation from both south-west and north-east monsoons. In South India the width of the sub-continent serves to take up most of the north-east and so deprives the Malabar coast of the benefits of this rainy period.

The Climates of the East Indies and the Kenya Highlands

The East Indies include the islands of Indonesia of which the two most important are Java and Sumatra. Coming within this climatic and geographical unit are British Malaya, British North Borneo and New Guinea, the last lying at the eastern

extremity of the Malay Archipelago. All these countries lie outside the monsoon area and have an equatorial climate with moderately high temperatures all the year round and evenly distributed rainfall.

Included in the table below is the average monthly rainfall of Siantar in Sumatra, the Cameron Highlands in Malaya, altitude about 4,000 ft., Soekaboemi in Java and Kericho in Kenya, altitude about 6,000 ft. Although Kericho is far removed geographically from the East Indies its climate is similar, in spite of the fact that its rainfall in the northern summer is to some extent reduced by the pull of the monsoon air current towards Central Asia from June to October.

In all four countries dealt with the Assam type of bush is grown with success and the China types are not now used. The temperatures of the Cameron Highlands are much below those in the low country of Java and Sumatra, but the crop distribution in all four areas is even, ranging from 7 to 10 per cent of the total each month.

Siantar and the Cameron Highlands lie about latitude 3° N. which may be compared with the latitude of the Ceylon tea districts, 6° N. Kericho lies practically on the equator, whilst the Java tea areas are about 7° S.

RAINFALL IN THE EAST INDIES AND THE KENYA HIGHLANDS

	<i>Siantar, Sumatra in.</i>	<i>Cameron Highlands, Malaya in.</i>	<i>Soekaboemi, Java in.</i>	<i>Kericho, Kenya in.</i>
January .	11.1	9.4	24.7	3.2
February .	7.2	5.8	11.2	5.3
March .	8.9	8.1	15.1	6.3
April .	8.7	13.4	16.1	9.7
May .	12.0	8.7	10.4	11.7
June .	6.7	6.4	6.5	8.3
July .	6.7	4.7	3.9	5.5
August .	9.6	4.9	3.8	7.1
September .	13.7	12.5	4.0	6.4
October .	16.7	14.3	9.1	5.7
November .	8.8	15.2	13.8	4.5
December .	9.8	13.0	16.4	2.2
Total	119.9 in.	116.4 in.	135.0 in.	75.9 in.

The East Indies are subject to a change in wind direction from April onwards as the thermic equator moves north, and another from November onwards as the Australian continent warms up and acts as a centre of low pressure, just as the Central Asiatic plateau does in the northern summer. The strength of the pull is not great and in whichever direction the wind blows it is always moist and laden with rain.

The Climates of Ranchi, Poti and Chipinga

Ranchi is in Bihar, 200 miles to the east of Calcutta, situated on a plateau, altitude 2,000 ft. Poti is on the Black Sea in Georgia, U.S.S.R., whilst New Year's Gift Estate, Chipinga is in the Melsetter district of eastern Southern Rhodesia. All three places have difficult climates for tea.

Tea was first planted in Ranchi in 1862 and a hardy China bush was used because the Assam type fails there. At the time of planting the plateau was forest clad, but with the opening up of the Damuda coalfields a need for pit-props was created and the forests were felled. Deforestation has no appreciable influence on the rainfall as is shown in Ranchi, in Mauritius and in Darjeeling, in all of which places records are available for periods before and after the removal of forests. There is evidence however that deforestation raises the day temperatures and thereby reduces atmospheric humidity. In Ranchi in the month of May the relative humidity may be as low as 20 per cent in the daytime, with dry bulb readings as high as 110° F. and under such conditions the spring flush may die back completely.

Today new tea can only be planted in Ranchi under dense shade like that of the mango tree or under a complete covering of a semi-permanent green crop. The care needed to bring new areas into bearing is such that planting is not a commercial proposition and tea in Ranchi will probably disappear as the present stand dies. The table below shows the average monthly rainfall and temperatures, together with crop distribution.

RAINFALL, TEMPERATURE AND CROP DISTRIBUTION IN RANCHI				
	<i>Rainfall</i>	<i>Temperature</i>		<i>Crop distribution</i>
	<i>in.</i>	<i>max. °F.</i>	<i>min. °F.</i>	<i>%</i>
January .	0·6	74	51	nil
February .	1·2	77	55	1
March .	1·1	87	64	6

	<i>Rainfall</i>	<i>Temperature</i>		<i>Crop distribution</i>
	<i>in.</i>	<i>max. °F.</i>	<i>min. °F.</i>	<i>%</i>
April . . .	0·8	96	72	16
May . . .	2·3	99	76	6
June . . .	9·0	92	76	7
July . . .	14·5	84	73	16
August . . .	13·6	84	73	15
September . . .	8·2	84	72	14
October . . .	2·8	83	66	12
November . . .	0·4	78	58	5
December . . .	0·2	73	51	2
Total	<u>54·7 in.</u>			

The average yield in Ranchi is about 160 lb. per acre, although good sections may give up to 400 lb.

The climate of the tea area in Georgia, U.S.S.R., is difficult because of low temperatures in the winter. The rainfall is ample but there is much snow. Although the tea industry has been established in the Caucasus for over fifty years, it is during the past twenty-five years that intensive study has been applied to the crop. Only the China type of bush grows, yet the yield now averages about 550 lb. tea per acre and the best areas give over 1,000 lb. The selection of suitable strains of tea able to withstand this rigorous climate has been of great benefit to the industry here. The table shows the monthly rainfall and temperatures at Poti, a place on the coast just north of Batum.

RAINFALL AND TEMPERATURES AT POTI, WEST GEORGIA, U.S.S.R.

	<i>Rainfall</i>	<i>Temperature</i>	
	<i>in.</i>	<i>max. °F.</i>	<i>min. °F.</i>
January . . .	5·2	59	29
February . . .	4·3	59	28
March . . .	3·2	71	30
April . . .	3·2	78	41
May . . .	2·3	82	50
June . . .	6·0	86	59
July . . .	6·0	86	64
August . . .	9·5	88	68
September . . .	9·0	82	55
October . . .	5·8	81	50
November . . .	4·6	72	40
December . . .	6·0	64	32
Total	<u>65·1 in.</u>		

The temperatures may be compared with those at Hankow, in which area yields are probably lower than those in Georgia.

The last table details the climate and crop distribution at New Year's Gift Estate near Chipinga in Southern Rhodesia. The estate was planted on the assumption that the precipitation was about the same as that of Chipinga, 45 in. However over the past 25 years the record shows an average of only 25 in., varying from 38 in. in the best to 18 in the worst year.

The terrain consists of a series of flats in a narrow valley and the lie of the land is ideal for irrigation from the Tanganda River. The tea is of the dark-leaved Assam variety, the stand looks healthy and under a canopy of shade trees resembles at a glance an Assam estate although the bushes are thinner. A crop of 800 to 1,000 lb. tea per acre is made. The irrigation of this estate is unique in the tea industry. The tea would probably die out without the irrigation which has been practised from the first planting in 1929. Yet in spite of the fact that the soil is watered, the crop distribution is the same as on neighbouring estates which are not irrigated during the six to seven months of the dry season. The cropping rate may be compared with that at Cholo, Nyasaland given in an earlier table.

CLIMATE AND CROP DISTRIBUTION AT NEW YEAR'S GIFT

		<i>Rainfall</i>	<i>Temperature</i>		<i>Crop distribution</i>
		<i>in.</i>	<i>max. °F.</i>	<i>min. °F.</i>	<i>%</i>
January	.	5·11	85	61	14
February	.	6·41	84	63	14
March	.	3·77	84	63	14
April	.	0·98	81	58	13
May	.	0·31	77	51	7
June	.	0·32	73	49	2
July	.	0·37	72	46	$\frac{1}{2}$
August	.	0·20	77	50	1
September	.	0·21	84	57	7
October	.	1·09	85	57	9
November	.	2·71	87	62	7
December	.	4·30	89	64	11 $\frac{1}{2}$
Total		25·78 in.			

It may be concluded that the tea plant in the China form will produce leaf economically over a wide range of climatic conditions, whilst the Assam form is more discriminating in its demands. Neither type however will give useful returns unless there is a warm, humid season in the year. Cold or cool dry spells are tolerated although during such times if the temperature fall from that of the warm season is sufficient, the bush will winter and cease to flush. Hot, dry periods if prolonged may make an area unsuitable for tea production. These points have all been illustrated in the present chapter.

CHAPTER III

TEA SOILS

Physical characteristics—Classification of tea soils—The acidity of tea soils—The food of the tea plant—The influence of soil on quality.

THE tea areas of the world are planted up on soils of widely different geological formation. In North-East India most of the tea soils are Quaternary and recent alluviums and the rest are mainly soils formed *in situ* from the gneisses and sandstones below. In South India and Ceylon much of the tea is planted on soils resulting from the weathering of Archaean rocks. The soil of Java consists of the products of eruptive rocks and most of the tea soils are derived from the weathering of volcanic ash, sand and lava of the Tertiary period. In East Africa the soils are derived from granites, gneisses, sandstones and more recent deposits of volcanic activities.

The geological origin of the soil is not important provided the latter has had time to weather and lose excessive lime by leaching. Tea will not grow well on limestone soils or soils which have recently been flooded with alkaline water. This aspect is of great importance and is discussed later.

Although tea can be grown on soil of almost any type, it does best on a medium or light loam. Like other plants it prefers a deep, friable soil well supplied with plant food, but it will grow on poor soils and in China and Japan it is often relegated to hillsides where other crops would fail.

The Physical Characteristics of Tea Soils

The tea plant will thrive on soil of practically any texture. In North-East India successful tea soils range from the lightest of sands to the stiffest of clays, and include silts and loams of all types. Some of the sands hardly merit the term soil, for they are merely collections of rock particles on which the chemical

changes due to climate have had as yet little effect. On the other hand, some of the yellow clays are so stiff that they would be unworkable but for the marked dry season which puts tilth into them. In Cachar tea grows vigorously on peat soils, *bheels* which have been drained although the permanent water table remains at a foot or two below the surface.

In Ceylon and South India the soils are old and have become red and lateritic. They consist mainly of sand and clay, with perhaps 10 per cent or so of silt. There is little difference between top and subsoil in physical make-up, a fact which suggests that the top soil has in many cases been dissipated by erosion, and what is left is denuded subsoil.

Areas which have recently carried jungle are best suited to tea because they are rich in plant food and are in good tilth. The natural vegetation of all tea land is forest, but in many parts of Assam, Ceylon and Eastern Africa the forest has been removed long ago and the land grazed. More work is necessary to develop these grass lands than is required with jungle soils.

The Classification of Tea Soils

The general classification of soils is a difficult task. Classification on a purely physical basis, dividing soils into sands, silts, loams and clays, is not sufficiently discriminating, whilst one based on geological origin is also unsatisfactory for the geological factor is often outweighed by the climatic one.

Climate is the ultimate factor which determines the make-up of a soil and, given time, in due course a certain set of climatic conditions will produce similar soils however much the original materials may differ. Under wet conditions, as in western Europe, with temperatures generally below 59° F. the water passing through the soil leaches out iron and aluminium and forms eventually a soil that is termed a *podsol*. When temperatures are generally above 59° F. however, as in most tea countries, the leaching removes bases like lime and magnesia, as in the case of *podsol* formation but silica is also washed through rather than iron and aluminium. In this way the proportion of the iron and aluminium left in the soil increases, and it becomes red because of the iron oxide. These changes are called laterization and the soils are described as lateritic or called *latasols*. The final stage of laterization is laterite, a mass

of red nodules composed practically of iron and aluminium oxides which set on drying to form a brick-like substance. In the Western Ghats of South India, where the process of laterization was first studied, lateritic bricks are commonly used for building. The word 'laterite' is derived from the Latin *later*, a brick.

Some measure of laterization was at one time based on the ratio of silica to the oxides of iron and aluminium in the clay fraction of the soil. If this was less than two, the soil was reckoned to be lateritic. On this basis, lateritic soils have been reported from the tea areas of Formosa, South-East China, Indonesia, Ceylon, East Africa and Nyasaland. In the tea districts of South India, soils formed even well above 6,000 ft. are on this basis markedly lateritic. Soils of North-East India are assumed to be lateritic but without analytical data. Japan tea soils have been described as *podsoles*, a form resulting from leaching at temperatures below 59° F.

Before leaving the subject of laterization it is noted that lateritic clays are porous and non-plastic, whereas podsollic clays formed under cool, humid conditions are more sticky and less permeable to water.

The hot, wet climate experienced in all tea districts for at least some months of the year brings about rapid decomposition of organic matter on the soil surface. In the heaviest tropical jungle there is rarely more than $\frac{1}{2}$ in. of plant debris on the soil surface and the accumulation of humus common in temperate regions is never seen. The clearing of a jungle soil and exposure to the sun for a couple of years in a clean fallow may lose by leaching half the nitrogen, which is the measure of the humus content. In Malaya it is recorded that in eleven weeks' exposure, the nitrogen content of a soil fell from 0.17 to 0.11 per cent. These conditions necessitate a close cover of the soil if fertility and tilth are to be maintained. On this account it is desirable and customary to plant a leguminous cover crop between the rows of young tea until the spread of the bush is sufficient to protect the soil from the sun.

The Acidity of Tea Soils

The question of soil acidity is a complex one. The arrangement of atoms of oxygen, silicon, aluminium and other elements

which constitute various clays, forms a space-lattice which carries a series of negative charges. These charges may be balanced with hydrogen atoms giving the clay colloid an acid reaction in the soil water. Calcium, magnesium, sodium, potassium and other bases may replace these hydrogen charges, first reducing the soil acidity then making the clay reaction alkaline.

In tea lands, much of the lime and other bases have been leached from the clay and the soil solution thereby becomes acid. The acidity of a solution is denoted by a scale of pH values, in which 7 denotes neutrality, whilst figures below 7 denote increasing acidity and values above 7 denote increasing alkalinity. The usual range of pH values is from 4, in very acid soils, to about 8.5 in strongly alkaline soils.

Practically all good tea soils in North-East India show pH values of about 5.4 and this is the value for most of the soils, both new and old, which have weathered under Assam conditions. The acidity is of a mineral nature. The peat or *bheel* soils of Cachar, which often contain 50 per cent organic matter, have pH values of 4 to 4.5 and here the acidity is due to the organic acids in the humus. The tea soils of Ceylon and South India generally show pH values from 4.6 to 6 although the extreme range covers 4.0 to about 7.0. In Japan, the most satisfactory values are said to range from 5 to 6. In Nyasaland and East Africa the common range is between pH values of 4.4 and 6.2. In the Caucasus, pH values are about 5.0 to 5.4.

The intensive study of the acidity of tea soils began in Assam in 1920 when it was shown experimentally in the field that lime was harmful to tea. It was at first thought that tea needed an acid soil solution and that lime, as such, was only a subsidiary factor in that it reduced acidity. Then odd areas in Assam, South India, the Dooars and Eastern Africa with pH values almost 7, indicating neutrality, were found occasionally to grow good tea. It was then assumed that although these soils were lacking in acidity they were not necessarily rich in available lime and that tea was perhaps a calcifuge, avoiding lime, rather than a plant seeking an acid soil solution. Another more recent explanation is that since acid soils contain much readily available aluminium and manganese, which the tea bush apparently consumes and stores in relatively large quantities,

it is the need for these elements that necessitates an acid soil for tea.

Whatever the explanation, it would appear that tea will occasionally thrive in a soil which is not markedly acid, although in opening up new areas such soils should be regarded with suspicion. On the other hand, if the pH value is about 5.4 no worry on the score of acidity need be felt.

In some estates, weak patches of tea are traceable to the burning of heavy timber and such areas are usually found to be under-acid. Old village and house sites are infertile for tea, a fact well known in India, Ceylon and Africa, and attempts to make them fertile usually fail. The addition of sulphur, fertilizers, cattle manure and green crops in reasonable quantities do not enable these patches to carry good tea. Analysis shows such places to be under-acid and rich in phosphates.

Before leaving the subject of soil acidity some mention may be made of the presence of the element calcium in the soil and its function in plant life. Calcium is usually spoken of in agriculture as lime and this term denotes the oxide CaO , quicklime.

Calcium is essential to all plants. It occurs in the region of cell division and of growth, and is thus found in the root tips and the apex of the stems. It is a constituent of the cell wall and accumulates in the leaf. Calcium deficiency stunts the root system and affects the leaf appearance. The dry matter in tea leaf contains about 0.55 per cent lime so that a crop of 1,000 lb. tea removes $5\frac{1}{2}$ lb. lime from the soil.

Calcium occurs in the soil minerals which in due course weather down and yield the element to solution. It occurs as calcium sulphate and as various phosphates, in fact superphosphate is a mixture of such substances. It occurs as limestone or calcium carbonate, CaCO_3 , although not in such form in acid soils. Lastly it occurs attached to the clay lattice or clay complex, as an exchangeable base. This calcium is available to the plant in various degrees, some easily, some with difficulty and some, in strongly acid clays, not at all.

Tea probably gets its calcium from weathered soil minerals and any odd calcium salts. It may, if pushed, get some of the exchangeable calcium from the clay lattice.

When sulphate of ammonia is added to the soil, the soil

acidity is increased and some of the lime washed out. In England it is stated that for each 1 cwt. sulphate of ammonia added to the soil the equivalent of 1 cwt. limestone is washed out. In the case of an acid soil with no free limestone, the calcium may be removed from the clay lattice, but whether the leaching from acid tea soils is as serious as the washing out of lime from a soil in England is not known. In Assam over a period of twenty years the pH of the soil has been reduced from 5.4 to 4.6 after annual doses of sulphate of ammonia giving about 2 cwt. per acre. How much the available lime content was reduced in that time is not known.

Although the tea plant thrives in an acid soil, it needs some lime, much potash and other bases. How long the leaching of the clay bases can go on without serious effects on the bush is a matter for speculation. Bases can be replaced by the addition of potash manures and by superphosphates and rock phosphates. In Assam, an easing up in the use of sulphate of ammonia and the planting of leguminous shade trees instead, is advocated as a method of raising yields which is safer than the addition of large doses of sulphate of ammonia.

The lime content of a good Assam tea soil is about 0.2 per cent of which about half is considered available to the plant. Figures are a little higher in Java and Ceylon. In Assam, the amount of available lime in the top 9 in. of soil is about 2,500 lb. sufficient to supply lime to an annual crop of 1,000 lb. tea for up to 500 years. However if leaching is serious, this quantity might well be washed out by sulphate of ammonia in a few years.

The Food of the Tea Plant

The original object of analysing soils physically and chemically was to give advice on manurial and cultural treatment. Many thousands of full analyses have been made of tea soils in most tea countries but, although these are an essential part of any soil survey, it has not been found possible to interpret the analysis in the form of practical advice. No chemical method has so far been devised of measuring how much of the plant food in the soil is available to the rootlets of the plant, although analyses include figures for 'available' lime, phosphates, etc. What in the way of fertilizers should be given to a soil can only

be determined by field experiment, the results of which often run counter to analytical figures.

Green plants build up tissue from simpler substances taken from the soil and the air. In this way carbohydrates, fats, proteins and a host of enzymes, pigments and other complex bodies are produced. For forming plant tissues, carbon, oxygen, hydrogen, nitrogen, phosphorus and sulphur are necessary. Small amounts of iron, magnesium, manganese, zinc, copper, boron and molybdenum are used in the make-up of the enzymes. The elements calcium and potassium are essential, and sometimes sodium. Aluminium, silicon and chlorine may be needed, and occur in all plants grown in soil. Altogether up to twenty elements are found in plants.

Hydrogen and oxygen are present in water, and carbon in the carbon dioxide of the air. Nitrogen is derived from the soil organic matter in the form of humus, although leguminous plants can fix it from the atmosphere, as can certain algae and bacteria found in the soil. Another external source of nitrogen is the rainfall which brings small quantities to the earth in the ammoniacal and nitrate forms.

The other substances needed by plants, referred to as minerals, such as potassium, phosphorus and calcium, unlike those mentioned in the last paragraph, come from the soil rocks by chemical and biochemical decomposition. Many of them are present in limited quantities and any one of them can only be added to the soil when taken directly or indirectly from the earth elsewhere. When a crop is harvested, minerals are taken away and, in this manner, cropping is in the nature of soil mining.

The three plant foods most commonly deficient, or those which most usually give crop increases when applied, are nitrogen, phosphorus and potassium, and these additions are generally made in tea estates in the form of sulphate of ammonia, superphosphate and muriate or chloride of potash. Other additions are usually of organic matter in the form of cattle manure, composts or green manures. Although these bulk manures also supply the three foods, nitrogen, phosphoric acid and potash, together with various trace elements and perhaps certain growth-promoting substances, their use is mainly to improve the tilth of the soil.

The dry leaf contains about 5 per cent nitrogen, $2\frac{1}{2}$ per cent potash and 0.8 per cent phosphoric acid. Hence a crop of 1,000 lb. tea removes about 50 lb. nitrogen, 25 lb. potash and 8 lb. phosphoric acid. However, the addition of fertilizers is not based on these figures any more than it is based on soil analytical figures. Manurial doses are based on the results of field experiments. Thus in Assam, sulphate of ammonia is usually added alone, because experiments with potash and phosphates show no crop increase. Sulphate of ammonia may be added up to the rate of 600 lb. per acre, because experiment has shown this to be economic.

In Ceylon, experiment has shown that all the three elements, N, P and K gain a response, and a complete mixture is added to tea areas. It is logical to assume that the removal of minerals from a soil by a large crop harvested annually will, in due course, catch up on and overtake the minerals made available as the rocks are weathered down to clay. It might be argued that on this account, minerals like P and K should be added now for the benefit of future generations of planters. However both potash and phosphates become insoluble and hence non-available to the plant in a year or two, so the situation is not a straightforward one. This aspect of soil management is reverted to in the next chapter.

In some cases tea has been found to suffer from lack of trace elements in the soil. Thus, in Nyasaland on certain tea areas at certain times there appears to be a shortage or non-availability of sulphur, and this is manifest in the leaf by a disease called Yellows. The addition of sulphur to the soil as the element or in combination as in sulphate of ammonia, eliminates the state producing this disease.

In a limited, localized area in Nyasaland, shortage of copper in the leaf occurs and since the enzyme which oxidizes the leaf in the fermentation process is a copper-protein compound, the tea grown in such areas will not ferment after rolling. Spraying the foliage with Bordeaux solution is sufficient to put matters right and one round of spraying lasts in effect for a couple of years. Bordeaux solution contains copper sulphate and its influence is apparent within about three days of application.

In Nyasaland, by spectrographic analysis, the trace elements in fine tea shoots have been found to include mainly aluminium

and manganese, each of which varies between 500 and 1,000 parts per million parts dry leaf. Iron is present by about 75 and boron 40 p.p.m. Zinc, 35, copper, 12 and nickel, 5 p.p.m. follow in descending order. Traces of barium, strontium, chromium, tin and lead have also been detected.

In Ceylon, the copper content is 25 p.p.m. and the zinc ranges from 25 to 42 p.p.m. Molybdenum has not been detected. The tea plant is a luxury feeder with regard to potash and phosphoric acid, and after a certain stage any extra minerals go to increase their content in the leaf and not to increase the total crop. In the same way the trace elements may possibly be assimilated and stored if they are present in comparatively large quantities in the soil. This may be an explanation of the different copper contents of tea grown in Nyasaland and tea grown in Ceylon.

The Influence of Soil on Quality

In China, the characteristic flavours which distinguish tea of one district from another are ascribed by Chinese farmers to the soil. Similar views are held in Japan. There is no scientific evidence in India, Ceylon or Java to show that quality goes with certain chemical or physical properties of the soil.

Recent study in India has shown that the inherent quality of the individual bush or the general quality of the *jat* of tea outweighs any other factor, be it climatic, soil or even fineness of plucking, in its influence on the quality of the made tea. Tea at the beginning of a flush has quality, as has leaf grown during a period when the atmospheric conditions are dry. The type of China-hybrid bush grown in Darjeeling produces outstanding flavour in the second flush. The Assam type grown in Darjeeling produces some flavour but not the same as the China hybrid, just as the Darjeeling type of bush grown in the plains of Assam produces some quality but not the same as the Assam bush. How far these differences may be due to soil is not known, but it is considered that the bush type and the climate are both more important factors influencing quality than is the soil.

Nitrogenous manures, whether in the organic form as cattle manure or the chemical form as sulphate of ammonia, affect quality adversely though to a very small extent. Even with

applications giving 400 lb. sulphate of ammonia per acre and producing yields of over 1,000 lb. per acre, tasters cannot consistently detect any deterioration in quality. Potash manures have no effect on the quality of Assam teas but tend to improve those in Ceylon. This may be because Ceylon soils are short in potash available to the plant. Phosphoric acid seems to have a slightly good effect on the quality of Assam teas but none on those of Ceylon. Lime has no apparent effect on the quality of tea.



CHAPTER IV

THE CULTURE AND PREPARATION OF TEA

The planting of tea—Pruning—Plucking—The cultivation and manuring of tea—The pests and diseases of tea—The preparation of tea—Tea manufacture—Mechanization and labour in the tea industry.

THE crop harvested from the tea plant comprises the young leaf shoots consisting of two to five leaves and the unopened bud. These are rich in the alkaloid caffeine, and in certain polyphenols. A treatment whereby the plucked leaf is given keeping qualities such that the caffeine it contains can be made available when needed serves, in the broadest sense, as a method of preparation of tea.

From the point of view of procedure in growing and preparation, the tea areas of the world fall into two groups. First there are the historic countries of China and Japan, where tea culture has been practised as a village industry for centuries. Methods in China are still primitive, but in Japan the value of science and machinery is fully realized and the industry there is as up to date in every way as in the modern tea lands.

The second group of tea countries includes India, Ceylon, Indonesia and Eastern Africa where the industry has been developed by European interests, producing tea wholesale primarily for western markets, and putting the results of science to the service of agriculture and manufacture. Outside China, tea growing took its rise in Assam just over a century ago.

In this chapter an outline of methods followed in various countries is given, partly with the object of indicating their differences.

The Planting of Tea

Tea is generally grown from seed. In Formosa, however, for many years much of the propagation has been by layering. In this way a lateral branch of a chosen bush is scraped of its bark

or an inch or so, and this portion is pegged into the ground and allowed to root. In Japan, for many years, both layers and leaf cuttings have been used to some extent.

Although in Japan, Indonesia, India and Ceylon, seed is the usual method of planting, intensive study of vegetative propagation is under way in all four countries. A selected bush may give 25 to 50 per cent more yield than the average, or produce tea with markedly better quality and strength, and these characteristics are absolutely repeated in the bush grown from a cutting and treated in a similar manner to the parent. Propagation by cuttings of selected clones or by seed taken from generative clones, is bound to become standard procedure in some form or other in due course.

In China and Japan seed is usually planted straight into the field, close together in a line or in circles of about 18 in. diameter. Thus a hedge is formed or a series of hive-shaped clumps which merge into each other giving undulating rows 4 to 6 ft. apart. In Japan the seedlings may be selectively thinned out.

In India and Ceylon nurseries are practically always used, with the seed spaced 5 to 8 in. apart. The nursery is shaded and watered, and after a year, eighteen months or two years the seedlings are transplanted in the field. In India the plant is lifted whole, with a clod of earth perhaps 18 in. long and 6 in. in diameter, and planted thus. The clod is unbroken, and this method is possible because planting is carried out in the dry season when the silty soil sets firm and hard. In Ceylon, Java and Eastern Africa, the stem of the seedling is cut at 6 to 8 in. above the ground at the time of planting, then the root is pulled from the loosened soil and planted as a stump. Clod is preferable to stump planting because there is less setback in the subsequent forming of the bush.

The plants are spaced in the field in lines 4 or $4\frac{1}{2}$ ft. square or triangular. On hillsides the spacing is sometimes 4 by 3 ft. in contours. At present there is a tendency to hedge plant, with spacing about 5 by $2\frac{1}{2}$ ft., partly in anticipation of the subsequent mechanization of plucking.

Pruning

In China and Japan, from the way the seeds are planted and the natural low-growing habit of the China bush, it might

be thought that there would be no need for pruning but this is not so.

In Japan, the year after thinning out the lines of seedlings, the shaping of the bush is begun. At the first pruning, the plants are cut evenly to about 12 in. high and thereafter, for the next five or six years at the end of each season the new growth is cut back to 4 in. In this way a compound bush 30 to 36 in. high is obtained. From then on the bushes are clipped level and trimmed at the close of the year, and the twigs and old leaves so produced are made into coarse tea or used to make brick tea.

At intervals of five to ten years in some areas, and up to twenty-five to thirty years in others, the bushes are rejuvenated by heavy cutting back. The mature bush consists of a clump of gnarled, single-stemmed plants, each branching to fill up its own area in the dome-shaped plucking surface which extends from the crown of the hedge down to the soil.

With the Assam type of bush and style of planting the problem is different. A single plant has to be dealt with which in its natural state would form a conical tree 15 to 30 ft. high. For the convenience of plucking this must be kept to a height of about 3 ft., and for the sake of yield it must be induced to spread about 4 ft. at the plucking surface to meet its neighbouring bushes.

In North-East India the bush is formed as follows. About a year after planting it has grown into a conical plant 4 to 5 ft. high, which is then cut across flat in November or December, 18 in. above ground level and perhaps one centre branch removed. The bush is allowed to grow up the following spring but is plucked, level with the ground, when it reaches about 30 in., and is kept plucked flat at that height. Next year or the year after it is again pruned back level to about 18 or 20 in. and in due course plucked flat again at 30 in. Then each year or alternate year the bush is cut back, a little higher each time, on 1 in. or $\frac{1}{2}$ in. of new wood. After twenty-five years or so, the bush may be getting too high for plucking, since this operation calls for a run of about 6 in. of new growth above the pruning level. In this event, the bush is medium pruned back to about 24 in., and the cycle of pruning started again. After a further fifteen to twenty-five years, total forty to fifty years from

planting, the area probably needs uprooting and replanting. However, many areas in Assam are at the age of sixty years still giving crops of 1,200 lb. tea per acre.

In Java a similar procedure to the above is followed. In Ceylon the length of the pruning cycle ranges from eighteen months to two years in the low country, three to five years in the high-grown areas, and the periodic cut is usually lower than in India. However there is a tendency towards higher pruning in Ceylon now, which is considered preferable to the low cut. In South India it has long been the custom to prune at heights comparable with those in Assam and to run four, five or even six years between prunings, the longer periods being used at the higher altitudes.

Plucking

In China and Japan the young leaf is plucked when each flush is complete and the biggest pluckings are made in the spring. Although several leaves are taken the growth is not coarse because the individual leaves are small. Only three to five pluckings a year are made.

In India, the China method was used in the early years of the industry but experience soon showed that more crop is made if the bush is allowed to retain some of its new spring leaf. Plucking in Assam is on a level table and never below about 27 in. above the ground. A run of not less than 6 in. of new growth is given above the pruning height before leaf is plucked, provided this initial run brings the table up to 27 in. All these measurements hold with bushes of the Shan and Burma types in which the stalk between leaves measures about 2 in. The initial plucking above 6 in. of new growth is therefore equivalent to leaving three leaves on the bush above the pruning, and taking the rest of the shoot above that height. Once the initial plucking table is established all shoots growing above that table are plucked when they have produced two or three leaves, or if they turn *banjhi*.

In Ceylon, after the rather heavy prune, the bush is left to grow till the shoots are so long that the new wood has turned from green to red at the base. This new growth is then plucked back or 'tipped' to about 4 in. above the pruning level. A second 'tipping', still higher, may follow, after which plucking

begins and this is above a big leaf. Hence to pluck two leaves and a bud, three leaves are allowed to grow and the lowest leaf is left on the bush at plucking time.

Thus two plucking systems are presented, top-pruning annually or biennially as in Assam, followed by flat plucking, against heavier pruning at longer intervals, followed by 'tip-ping', which resembles the Assam top-prune, and then plucking above a leaf, as in Ceylon. Perhaps with the lighter pruning in the low country of Ceylon, where the cycle is only eighteen months to two years, closer plucking might pay.

Plucking is defined as *close* or *long* according to the length of the growth left above the pruning or above the last plucking level. To pluck on a 4-in. growth above the pruning is close plucking, as opposed to an 8-in. growth which would be long plucking. The size of the shoot is designated by the terms *fine* or *coarse*. Two leaves and a bud is fine plucking whilst three leaves and a bud or more is considered coarse. Both pruning of the correct severity and at the right intervals, and plucking to the right degree of closeness, stimulate the bush to produce its maximum crop commensurate with the amount of fertilizer applied to the soil. A nice balance in pruning and plucking calls for experience and local knowledge. This subject is expanded in the chapter dealing with these operations in North-East India.

In India, Ceylon, Java and Eastern Africa, the bushes are plucked at six- to ten-day intervals, according to the season, and only the ready leaf is taken, that is the shoot of two or three leaves and a bud according to the fineness of the pluck being employed. Unready shoots which protrude above the plucking table or have not grown sufficient leaves, are left till the next round. Thus close discrimination on the part of the plucker is called for.

The Cultivation and Manuring of Tea

Tea, like most plants, grows best on a clean soil free from weed competition. During the first two or three years in the field, it is very desirable to keep the soil around the plant clean of weeds and this task is given precedence over others.

Regarding the cultivation of the soil, Chinese practice suggests a loosening in March and cultivation in the summer to

destroy the weeds. After the plucking season is over the soil is once more cultivated. In Japan the soil is usually hoed four times in the year, first about mid-March and subsequently about once a month between the four pluckings.

In North-East India field experiment and experience have shown that soil disturbance *per se* does little to increase the crop, but that the removal of weeds does good. At one time tea estates were deep hoed to 9 in. each dry season and light hoed six or more times during the year to a depth of 5 in. Trenching and the burial of prunings at 18 in. was customary. Nowadays the cultivation consists of one round of scrape hoe in the spring, whilst the boles of the bushes are cleaned round once in February. The weeds are sickled three or four times over the rest of the year. The prunings are left on the surface to rot, for burial brings no increased benefit. The wide spread of the bushes and the canopy of shade trees do much to keep the weed growth in check.

In Ceylon cultivation follows an entirely different line from that just described. The standard operation is envelope forking whereby an 18-in. fork is driven about 12 in. into the ground and the soil loosened. If organic matter in the way of light prunings is available, this is pushed into the envelope formed by levering the fork forward. This forking leaves the area in a series of little parallel ridges which hold the water and reduce erosion. Apart from this, the soil in Ceylon is kept clean weeded. Often weeds are destroyed although sometimes they are collected, rotted down and replaced on the soil. Ceylon procedure, like that in North-East India, is based on experiment and experience.

In South India, procedure in cultivation lies somewhere between that in Assam and that in Ceylon, although the soils there and general conditions resemble closely those in Ceylon. The whole problem of cultivation needs further consideration.

Turning now to the question of the manuring and fertilizing of tea, wide differences are again shown in different countries. In China it is considered that the manuring of bushes producing leaf for black tea loses quality, although not so with green tea. In Japan, where green tea is the main outturn, enormous quantities of plant foods are added, mainly as organic manures. The recommended annual dose includes about 400 lb. nitrogen,

100 lb. phosphoric acid and 200 lb. potash. Such doses go with yields of 3,000 lb. and more tea per acre, compared with 1,000 lb. outturns in India or Ceylon.

In North-East India the Shan type of tea grown in the full sun responds markedly to additions of nitrogenous manures, and sulphate of ammonia adds about 8 lb. tea per 1 lb. nitrogen supplied as fertilizer. So far no response to potash or phosphate is generally obtainable. With tea grown under the shade given by leguminous trees such as *Albizzia stipulata* planted 40 by 40 ft., at which distance the shade canopy reduces the light intensity by 50 per cent, the response to sulphate of ammonia is reduced to about half the figure just quoted. The tendency in North-East India is towards a kind of silviculture in tea, whereby the plants are grown under leguminous shade which reduces the need for both fertilizers and weeding.

In Ceylon the tea responds to all three elements and a complete mixture is given, sufficient to replace the amounts of these foods removed by the crop and the prunings. The use of leguminous shade in Ceylon is not as highly developed as in India, and a common shade tree is the *Grevillea robusta*, a non-legume.

The Pests and Diseases of Tea

The tea bush is subject to attack by many insect pests and fungus diseases. The most widespread pest is the Red spider, *Metatetranychus bioculatus* which can be controlled by lime-sulphur spraying. A few years ago the Tea mosquito bug, *Helopeltis theivora* was the most serious pest but this has been brought under control by D.D.T. spraying and is now of minor importance. Various crickets, beetles, borers, caterpillars, bugs, thrips and mites all do more or less damage at certain times and in certain districts, but only occasionally are their depredations of such economic importance that control measures are justified.

The tea plant is attacked by many fungi which bring diseases to the leaves, stems and roots. Fifty years ago only about a dozen disease-producing fungi were definitely identified on tea. At present about 150 diseases have been reported. In Ceylon fifty-five species attack tea, in Assam thirty-five, but in East Africa less than twenty have so far been recorded.

In Assam the main fungus disease is Black rot, due to

Corticium invisum which attacks the leaves and blackens both flush and older leaves. Control is obtained by copper fungicide sprays. Blister blight, *Exobasidium vexans* has received much publicity of recent years. Although it was first reported in North-East India in 1858 it was not known in the other tea countries till in 1946 it appeared in South India, then in Ceylon, Malaya and Indonesia. This fungus attacks the young leaves and may kill pruned bushes which are just putting on foliage. The crop loss has been variously reported as 20 to 25 per cent in certain districts of South India. Power dusting and spraying with copper fungicide has brought the fungus under control in South India and Ceylon, and the way in which the disease has been dealt with is a fine example of co-operation between estates.

Since 1935 the invention of new insecticides and fungicides, and the improvement of spraying and dusting machines has done much to reduce the losses from pests and diseases.

The Preparation of Tea

Fuller details of the preparation and the manufacture of tea are given in subsequent chapters. In the present and the next section the briefest outline of the various processes will be stated. The term preparation, is used to denote a simple village process of making tea, whilst the term manufacture, indicates procedure as followed in India and Ceylon tea factories.

The tribes of the Shan States of Upper Burma and Upper Siam steam the fresh tea leaf above boiling water, thereby killing it, and preserve it in pits lined with leaves or ram it into bamboos. The extract of these pickled leaves is drunk and the leaf itself chewed by the Shans when they have heavy work to do. These people also make green tea by first killing the leaf in steam, then rolling it on bamboo mats and drying it in the sun.

The early Chinese steamed the leaf, then dried it over a fire and pressed it into cakes or crushed it into a powder. By the eighth century A.D. the steaming was followed by rolling between the hands and after drying the leaves remained separate. If the leaf is damaged by rolling before it is killed by steaming, certain chemical changes take place and so-called black tea results, as opposed to green tea which is otherwise made. Cake

tea was boiled, powdered tea was whipped, and leaf tea is steeped in water and the brew used as a beverage. The present-day method of manufacture of green or black tea is founded on the original China process.

In China the leaf is sometimes steamed, rolled and sun-dried, in making green tea, but a better product is considered to result if the leaf is first killed in a hot pan. After the heating process the leaf is rolled for a time and then put back into the pan for further drying. Rolling and panning alternate till the leaf is too crisp for more handling, after which it is dried in the fumes of a charcoal fire.

It will be appreciated that the making of green tea using a hot pan calls for much handling for only about 15 lb. leaf go to one pan. Green tea made in China is panned, as it is in Dehra Dun and the Kangra Valley in northern India. When great quantities of leaf have to be handled, panning is out of the question so the leaf is packed into large revolving drums each taking 300 to 400 lb. and steam is blown through the trunnion. In Japan, the leaf is steamed in this manner. In India and Ceylon, where occasionally green tea is made in large quantities for special contracts, the leaf is steamed in drums and subsequently rolled and fired in the machines used for making black tea. In Japan the treatment of the leaf after steaming takes place in special rollers, as described in the chapter dealing with that country.

The preparation of black tea is more complicated than that of green tea. In China the process is one capable of an infinite number of variations and the following account can only be taken to cover the general case.

First the plucked leaves are quickly withered in the sun for about two hours with frequent turning. They are then spread thinly in a cool place for about half an hour, after which they are manipulated and gently rolled in the hands. The rolling cracks and bruises the leaves and exposes some of the leaf juices to the air. After rolling, the leaves are again spread thinly in a cool place for a short period and then rolled again. Rolling and spreading alternate several times till fermentation has proceeded far enough, as judged by the aroma. Fermentation is now stopped by throwing the leaves into a hot iron pan heated to a temperature of 160° F. or higher. The leaves are

cooled and then rolled again and manipulated, and again placed in a hot pan and partially dried. Alternate rolling and partial drying take place several times and the leaves are finally dried on bamboo trays over a charcoal fire.

The preparation of Oolong tea is very similar to that of black tea in China. Details of the process are given in the account of tea in Formosa, which country produces the finest Oolong teas.

Brick tea is made in China for export to Mongolia, Tibet and Russia. Some years ago its preparation in India was seriously considered, but the project was not developed. Brick tea intended for Tibet consists of leaf, stalk and even twigs, whilst that for the Russian market is made mainly from tea dust and siftings. Both black and green teas are compressed into bricks and tablets.

In the modern factories at Hankow, which used to supply the Russian market, the carefully graded dusts were steamed in cotton bags and poured into wooden moulds in which the brick was formed by hydraulic pressure. The making of the poorer grade bricks for Tibet is largely in the hands of the Chinese. The leaf is steamed until it is moist and pliable and then rammed into wooden moulds, where it is left to dry and harden.

Tea Manufacture

When tea cultivation first started in India in 1835, Chinese were imported and Chinese methods were employed both in the field and in the factory. As the industry developed hand methods were first simplified and then mechanized.

By the China process as first employed for black-tea in Assam there were about twelve operations lasting over three days, including withering, four spells of rolling, two pannings, one sunning, two firings and so on. First, the withering process was simplified by the planter, and the leaf was put on bamboo trays and kept in a shed overnight. Next, panning was abandoned and the withered leaf simply hand rolled, then fermented and dried in a kind of chest-of-drawers with four or five iron wire trays over a charcoal fire.

Most of the labour was occupied in hand rolling, for a man could only deal with 30 to 40 lb. withered leaf a day. The first machines were rollers introduced about 1870 and by 1890 the

roller as known today was in use. Drying machines soon followed, first with a natural draught and then with a fan to force the hot air through the leaf. By 1890 the industry was mechanized in the factory with rollers, dryers and sifters.

In the last fifty years much progress has been made. In Ceylon the withering loft has been developed to a high degree of efficiency. Apart from mechanical improvements the roller has not changed in principle. Aids to rolling are in use and these include the C.T.C. and the E.J. machines. The greatest advance since 1890 was probably made in 1907 with the introduction of pressure dryers in place of the suction machines of the Paragon type.

Apart from improvements in machinery and equipment there have been other changes, one worthy of mention being the realization of the need for bacterial cleanliness in the factory, and another the efficient control of the firing operation with the help of dial thermometers. Both these factors have made for brisker and brighter teas.

The assortment of the leaf has changed radically to meet market requirements. Up to 1900 the Pekoe grade was the best and comprised 40 to 50 per cent of the make, followed by Pekoe Souchong, whilst Broken Orange Pekoe was an inferior grade included with the Broken sorts and Dusts, as the Fannings were designated. It was not till about 1920 that the demand for Broken grades became all-important, although many concerns continued to produce 25 per cent leaf grades, Orange Pekoe and Pekoe, for some years after that. Nowadays the chief call is for Broken grades and Fannings.

The procedure in making black tea in India, Ceylon, Indonesia, Eastern Africa, Iran, Turkey and Georgia is roughly the same, and all these countries use the same machinery and equipment.

The withering period lasts from about sixteen to twenty-four hours, and the leaf is spread on wire or hessian racks at about 1 lb. to 9 sq. ft. if possible. During withering 100 lb. leaf dry to about 75 lb. in India and 65 lb. in Ceylon. When controlled lofts are used the temperature is kept as low as practicable and not above 80° F. for preference. In Assam, natural withering temperatures go to 90°.

In Assam, the leaf is generally given two half-hour rolls. In

the first roller 280 lb. leaf is about the ideal charge and after rolling there is a green sift, which may remove 10 to 20 per cent fine leaf which goes straight to the fermenting room. The coarse leaf is again rolled and green sifted to give a further 10 to 20 per cent fine leaf. The two lots of fine leaf are fired separately and give rise to the fine grades, Broken Orange Pekoe and B.O.P. Fannings. The bulk leaf is cut after firing and gives the so-called cut grades, Broken Pekoe, Pekoe Fannings and the Souchongs. Dust comes from both fine and coarse leaf.

In Ceylon, with a fuller wither, perhaps harder leaf, lower temperatures, slower moving rollers and so on, four half-hour rolls are common although five or six may be given.

After rolling the leaf is put in a cool place and spread about $1\frac{1}{2}$ in. thick to ferment, the total fermenting time including rolling being two and a half to three and a half hours. With all the processes in tea manufacture there is a wide range of times and conditions which may be varied without appreciable change in the value of the product. The need for coolness both in rolling and fermentation is fully realized and temperatures not above 80° F. are necessary if strength in the liquors is to be developed and conserved. If quality is present, temperatures should be at 70° or lower.

The tea is dried or fired in a specially designed dryer with moving trays carrying the leaf from the feed to the exhaust, against a blast of hot air which enters the dryer at the bottom at a temperature of 180° to 220° F. As the blast passes through the incoming leaf its temperature falls till at the exhaust it is only 120° to 130°. Firing conditions have been worked out with great care. In Ceylon, with fully withered leaf, the process is carried out in one operation, whilst in North-East India where the leaf is lightly withered the tea is fired in two operations. Details of times and temperatures are given in the next chapter where drying or firing is considered from the chemical and physical points of view.

All this organization and control in tea manufacture, together with the cultivation of the big-leaved type of bush, has produced a very different tea from the China commodity. The teas of India, Ceylon, Indonesia and Africa are generally brighter, brisker and stronger than China teas.

The above outline of procedure represents the normal, and as

such produces a certain liquor which the buyer wants. Drastic changes, e.g. the omission of the wither or the instantaneous crushing of the leaf instead of the leisurely damage done in the roller produce a different liquor which, because it is not normal, is not so highly valued. Apart from such fundamental changes in manufacture, experiments involving small changes are constantly in hand but very few of them are sufficiently worthwhile to warrant adoption. As labour charges increase, new methods may be forced on the industry, although they may produce teas different from the present outturn.

Mechanization and Labour in the Tea Industry

In Assam it is reckoned that for every 10 mds. (800 lb.) tea per acre made, one worker is necessary. Thus on a 1,000-acre estate which averages 1,200 lb. tea per acre, 1,500 workers are needed. Of these perhaps 150 are engaged in the factory and on services. It takes five women to pluck 1 acre of tea in the full season, so that plucking on a seven-day round in a six-day week on the property under consideration, about 170 acres per working day will be plucked, taking 850 pluckers. A woman can pluck 40 to 60 lb. leaf a day. Another major field occupation during the cropping season is weeding, still done by hand, which may well take 200 workers. Thus over 1,000 workers are accounted for in the field during the four or five rush months.

In the factory, mechanization has gone as far as can be expected at present. When leaf was hand rolled, one man dealt with 30 to 40 lb. withered leaf a day. An ordinary present-day roller will take a charge of 400 lb. if required and will deal with not less than 4,000 lb. leaf in a full day. Some of the biggest rollers take a charge of 800 lb. leaf. Two men can deal with the leaf for one roller.

A modern dryer can turn out up to 640 lb. tea per hour and occupies a fraction of the space taken by the pans and baskets used in the early days. Three or four men can manage a dryer.

In the field, the uprooting of bushes and cleaning the land ready for planting has been done by tractor for many years, although on some estates the work is still done by hand just in order to provide work for the men in the off-season, when there is no manufacture or weeding.

The key to the whole problem of mechanization is plucking, which takes almost 60 per cent of the labour force during the rush months in Assam and about 45 per cent in Ceylon. Plucking machines have been under trial for some years but the discrimination needed in taking only the shoots which are ready is beyond the scope of any ordinary mechanical cropper.

In Japan, for the past fifty years, the bushes have been plucked with light shears, one blade of which is fitted with a wire cage or cotton bag and the other with a scoop to push the cut leaf into the cage or bag. By hand a woman will pluck in a day 25 to 30 lb. of small leaf in Japan, but with shears 200 to 250 lb. may be harvested by a woman and 300 lb. by a man. When shears are used the tea is flush plucked, and anything up to five or six leaves and a bud will be brought in. Each field in Japan is plucked only four times in the season and enormous crops are made. The rough leaf thus harvested can be to some extent sorted green, and generally cleaned up during manufacture.

In Georgia, U.S.S.R., plucking machines have been under trial for well over twenty years. At present a self-propelling machine which runs on the soil between hedge-planted tea and cuts the bushes in the line thus straddled is being developed. The plucking apparatus consists of a pneumatic comb with mobile rubber-covered teeth which press the shoots against immobile teeth and thus break them off. The pluck constitutes 80 to 85 per cent young leaves, 10 per cent coarser leaf and the rest twigs and old leaves. A similar pluck results from the use of plucking shears when tea is flush plucked.

Trials with mechanical pluckers in India, Ceylon and Eastern Africa with tea plucked on a weekly round have produced conflicting results, but the general opinion is that such practice gives slightly less crop than with hand plucking and makes for little saving in costs.

Whether full mechanization in tea culture is at present desirable in India and Ceylon is an open point, for it is clear that such must involve plucking if it is to be effective. Apart from the depreciation in quality which is inevitable with mechanical plucking, the finding of alternate work for displaced labour presents a further problem. Yet, Australia, where labour is highly paid, is now considering tea culture, and in

that country mechanical plucking will be essential if economic production is to be achieved. Teas harvested by shears or clippers may not look as attractive or taste quite the same as those made from fine leaf selectively plucked, but such clipped-leaf teas may well secure a place in the world's markets in the next few years.

CHAPTER V

THE CHEMISTRY OF TEA

The polyphenols in tea leaf—The chemistry of tea fermentation—The liquoring qualities of a tea infusion—The aroma of tea—Micro-organisms on tea leaf—Tea manufacture and biochemical change.

THE earliest work on the chemistry of tea was carried out in 1827 when an alkaloid was found in China tea and called theine. An alkaloid called caffeine had been discovered in coffee in 1820, and when it was shown later that theine was identical with caffeine the former term was discarded. Caffeine also occurs in maté and several other plants.

Between 1840 and 1860 various tannin bodies were found in tea and by 1880 fairly full analyses of made tea were available. By 1890 analyses of fresh leaf gathered in Assam had been made, and it had been shown in Japan that the main change in black tea manufacture involved a decrease of water-soluble tannin in the leaf. By this time analyses showed the amount of fibre, protein, tannin, caffeine, ash, sugar and colouring matter in the leaf.

At the turn of the century systematic work on the changes taking place during tea manufacture was being carried out in India, Ceylon and Java. The tea essential oil, responsible for flavour, was studied in Java, as were the chlorophyll and allied pigments in the leaf together with the red and yellow colouring matters, anthocyanins and flavones. In Japan the sugars in the leaf were estimated, together with the cellulose, gummy matter, starch and amino-acids.

It was found that during withering the leaf continues to respire, evolving carbon dioxide gas and, as a result, the total solids in the leaf decrease by 3 to 5 per cent of the total. After plucking, certain building-up processes which take place within the living leaf are apparently reversed and on this account there

is a small increase in the sugars and in the amino-acids, made at the expense of the breakdown of starch and proteins respectively. Slight though these changes are they may be important in their connexion with quality in the made tea. This increase in sugars and amino-acids after the leaf is plucked proceeds whether the leaf physically withers or not. There is no change in the tannin content during withering.

In the tea factories over these early years much information regarding manufacture was gained in a practical manner. Each invoice of tea made is described and valued by several tea tasters and, since records of factory conditions are kept, factory work is by way of being an endless experiment, albeit rough and ready. In this manner it was observed that a period of about eighteen hours gives the best wither, when 100 lb. leaf dry to 65 to 75 lb. depending on the temperature. High temperatures during the wither were found to be harmful, indeed high temperatures are inimical to quality at any time during manufacture.

In 1901 it was shown that when the leaf is rolled or damaged, it absorbs oxygen with the aid of an enzyme, an oxidase occurring naturally within the leaf. This fact was established in Java, Japan and Ceylon almost simultaneously. In Japan it was concluded that the preliminary heating of the leaf in green tea manufacture, either by steam or in a hot pan, inactivated the enzyme and this accounted for the difference between green and black tea. During the fermentation process tea tannin, considered to be a catechol tannin, is oxidized and then condensed to form red and brown products, the former being desirable and the other not. The enzyme is inactivated at about 160° F.

Long experience in the factory showed that the fermentation process must be stopped after about three hours from the start of rolling, otherwise brown tannin products are formed at the expense of desirable red ones, whilst briskness and strength in the liquor give place to dullness and softness.

The oxidation process in black tea manufacture is misnamed fermentation. True fermentation denotes the decomposition of carbohydrates by yeasts to form alcohol and gas or acid and gas. Although various workers have suggested that true fermentation may go on during tea manufacture since yeasts

exist on the leaf and traces of alcohol have been detected in fermenting leaf, it is doubtful whether any fermentation takes place. The enzyme which oxidizes the tannin during the so-called fermentation is not a living micro-organism, but a catalyst.

It was shown that fresh tea leaf carries a considerable bacterial flora, and foreign bacteria may be introduced during manufacture to give taints to the tea. Fermenting leaf may also carry moulds, and species of *penicillium*, *aspergillus*, *mucor* and *dematium* were found. The subject of bacteria on tea leaf is dealt with again later.

This then, in 1930 was the state of the scientific knowledge on the make-up of fresh tea leaf and on the changes going on during the manufacture of black tea. A typical chemical analysis of fresh leaf and the black tea made therefrom based on this knowledge is given in the table below.

COMPOSITION OF TEA LEAF AND BLACK TEA

		<i>Fresh leaf</i>	<i>Black tea</i>
		%	%
Cellulose and crude fibre	} insoluble	34	34
Proteins		17	16
Chlorophyll and pigments		1½	1
Starch		½	¼
Tea tannin	} soluble	25	13
Oxidized tannin bodies		nil	4
Caffeine		4	4
Amino-acids		8	9
Gummy matter and sugars		3	4
Minerals (ash)		4	4
Total ash		5½	5½
Tea essential oil		nil	traces

Such a table assumed there was only one tea tannin, and this was difficult to estimate in the various forms in which it occurred in black tea.

In 1930, information of a more precise nature on tea tannin began to accumulate which was in due course to change the whole aspect of the study. It was later shown that there are several tannin bodies in tea, some very closely related, belonging to the catechin group of polyphenols.

The Polyphenols in Tea Leaf

Detailed knowledge of the tannin bodies in tea began with the isolation of (l)-epi Catechin from tea leaf in Japan in 1929, soon followed by the separation of (l)-epi Catechin gallate, whilst in Java, gallic acid was separated from the polyphenol mixture in tea leaf. Meanwhile the study was pursued in Assam and Ceylon, and then taken up in London in 1940. Here, by using a new technique of partition chromatography, whereby complex mixtures of closely related substances may be separated, dried green tea leaf was shown to contain a number of ether-soluble polyphenols including those found earlier in Japan. These comprise about 80 per cent of the polyphenols in the leaf.

Further study followed in Assam where the tea polyphenols were shown to include (a) simple catechins containing one catechol group per molecule (b) gallocatechins containing one pyrogallol group per molecule (c) galloyl esters of simple catechins containing one catechol and one pyrogallol group and (d) galloyl esters of the gallocatechins containing two pyrogallol groups. These substances are flavanols, the structures of which are known. Another substance which occurs in the polyphenol mixture has been shown to be a depside of gallic acid.

These identified polyphenols occur in practically the same proportion in leaf of different types, and any slight variations are not sufficient to explain the marked differences of quality observed in manufactured teas. Trace amounts of a great number of other polyphenols have been detected in tea leaf, but in insufficient proportions to be of significance in determining liquoring qualities.

The distribution of polyphenols in various parts of the shoot has been studied and has been found to vary, and such probably accounts for the different character of the liquors made from different parts of the shoot. Thus the depside of gallic acid decreases from the bud to the more mature leaves, whilst the simple catechins increase.

As the leaf gets older the polyphenol content becomes less. This is shown both by analysis and microscopic examination and was, of course, fully realized many years ago. Most of the polyphenols are concentrated in the upper surface of the leaf,

less in the lower surface and few in the centre (of the thickness). The polyphenols vary inversely as the starch content of the leaf, the more the starch the less the polyphenols.

It is of interest to record the distribution of polyphenols, caffeine and amino-acid nitrogen throughout the tea shoot plucked in Assam. The high value of the last in the upper stem should be noted, and further reference to this figure is made later in connexion with theanine.

ANALYSIS OF TEA SHOOTS IN ASSAM

<i>Part of Shoot</i>	<i>Polyphenols</i> %	<i>Caffeine</i> %	<i>Amino-acid nitrogen</i> %
Bud . . .	26.5	4.7	0.87
First leaf . .	25.9	4.2	0.68
Second leaf .	20.7	3.5	0.57
Third leaf . .	17.1	2.9	0.51
Upper stem .	11.5	2.5	1.03
Lower stem .	5.3	1.4	0.69

The Chemistry of Tea Fermentation

With all this newly won knowledge on the polyphenols in tea leaf it is now desirable to consider what happens to them during fermentation. The enzyme which assists in the oxidation of the polyphenols when the tea leaf is damaged and the juices exposed to the air, is an oxidase of the copper-protein type. It is located in the chloroplasts of the leaf cell, and the polyphenols are located in the vacuole.

The enzyme activity decreases slightly during withering, so that in fresh leaf it is more active than in withered rolled leaf. In fermentation, the activity of the enzyme decreases at temperatures above 80° F.

A detailed description of the tea leaf cell would be out of place here. Suffice to say that in the intact leaf, the enzyme and the polyphenols in the cell are separate, kept apart by a semi-permeable membrane. When the leaf is withered and rolled, microscopic examination shows that comparatively few of the outer cell walls are damaged, yet estimations show 90 per cent or more of the polyphenols are oxidized during a three-hour fermentation and in due course they are all oxidized. It hence appears that when withered leaf is rolled the enzyme and the

polyphenols are mixed without necessarily breaking up the whole tissue.

In the non-wither type of manufacture, when the fresh leaf with turgid cells is cut finely in a tobacco-cutter, a far greater proportion of the cells are visibly damaged than in rolling, and if the cut be as fine as $\frac{1}{64}$ in. most of them may be damaged if the knife is blunt.

When withered leaf is twisted in rolling, the semi-permeable membrane within the cell is apparently ruptured, allowing enzyme and polyphenols to mix. If tea leaf is placed in chloroform vapour, or is heated to about 120° F. or is frozen, it turns reddish brown owing to the oxidation of the polyphenols. It is likely that in these cases also, the cell walls are unbroken but the semi-permeable membrane within is ruptured.

When the tea polyphenols are first oxidized it is considered that ortho-quinones are the initial products. These substances are effective bactericides and this accounts for the marked fall in the numbers of bacteria naturally occurring on the leaf which takes place when the rolling starts and juices are expressed. Further oxidation after this preliminary action probably takes place.

The polyphenols are oxidized successively, not simultaneously and it frequently happens that the simple catechins are not appreciably oxidized by the time the fermenting leaf is taken to the dryer about three hours after rolling was initiated. During fermentation a considerable amount of gallic acid is produced, originating from the breakdown of the galloyl esters. The substance considered to be a deposite of gallic acid, mentioned earlier, is not appreciably oxidized during fermentation.

After oxidation the polyphenols begin to condense or polymerize, to form complex bodies and there is probably a whole range of these substances which give briskness, strength, colour and body to the tea liquor. Some of the lower polymers are soluble in ethyl acetate and are associated with highly desirable characteristics in the liquor. These lower polymers combine with caffeine probably to give the property in a tea infusion known as briskness. When a tea infusion cools, a precipitate called the 'cream' separates out and this is composed of the lower polymers combined with caffeine. The

higher polymers are considered to account successively for strength, then colour and body, whilst the highest polymers have harmful or negative characteristics and make for softness. It will be appreciated that there is a limited quantity of polyphenols in the leaf, so that one liquoring characteristic can only be increased at the expense of another and that marked colour and body may accompany a lack of briskness and strength.

Examples of polymerization or polycondensation are common in biochemistry, and the degree of condensation is affected by concentration and by temperature. It will thus be appreciated that the particular polyphenolic bodies produced in tea leaf during fermentation will depend partly on the degree of the wither and on the temperature at which the fermentation takes place.

It has been found that as the degree of condensation of the polyphenols increases, so does their ability to combine and form insoluble compounds with proteins, in other words their tanning properties increase. As condensation increases, solubility decreases. Hence a high degree of condensation robs the tea infusion of solid matter on two counts, insolubility of the polymer and precipitation by proteins.

The chemical changes occurring in the so-called tea fermentation appear to be restricted largely to oxidations and subsequent condensations of the polyphenols.

The Liquoring Qualities of a Tea Infusion

In 1944 in London important work was published regarding the relationship between the chemical make-up and the qualities of a black tea infusion as judged by taste, colour and creaming down. When tea is treated with boiling water, the substances extracted may be divided into four groups, viz. inorganic salts, caffeine, gummy matter, and non-nitrogenous substances which are astringent and give a green or blue coloration with ferric (iron) salts. This last group of substances is comprised of catechins, oxidized and non-oxidized, the former in various stages of condensation. Some of these catechin or polyphenolic bodies are extractable from the water infusion with ethyl acetate, and in the discussion which follows such bodies are called extractable catechins and the others non-extractable catechins.

Five teas were analysed with regard to the contents of the above substances, a common Sylhet, a very fine Assam, a Ceylon, a Dooars tea and one from Nyasaland. The Assam and Sylhet teas differed most and their analyses are first detailed. From 100 gms. tea the following quantities of the above five groups of solids were extracted:

	<i>Assam tea</i> <i>gms.</i>	<i>Sylhet tea</i> <i>gms.</i>
Extractable catechins	13.2	8.5
Non-extractable catechins	11.5	10.8
Caffeine	4.9	3.4
Gummy matter	9.2	11.9
Inorganic ash	3.8	3.4
Total	<u>42.6 gms.</u>	<u>38.0 gms.</u>

The gummy material and the inorganic ash contribute little to taste or colour of the infusion and may be considered unimportant so far as liquoring qualities are concerned.

Caffeine is a minor component of taste, although it is important in that it forms part of the 'cream' when the liquor cools. Hence it may be concluded that the catechins are the solids which contribute materially to the liquoring qualities of tea. Furthermore, in view of the fact that the non-extractable catechins are in approximately the same proportion in both teas under consideration, it is evident that the extractable catechin fraction is the important one so far as liquoring quality is concerned.

The ethyl-acetate extractable catechins form an orange coloured solution and with caffeine are very astringent to the taste. The catechins non-extractable by ethyl-acetate give a dull brown solution, weakly astringent and having the taste of poor, weak tea.

The 'cream' which separated from the infusions of the above two teas on cooling had the following compositions, shown as gms. per 100 gms tea extracted:

	<i>Assam tea</i> <i>gms.</i>	<i>Sylhet tea</i> <i>gms.</i>
Extractable catechin plus caffeine	8.25	2.95
Non-extractable catechin	3.14	1.65
Inorganic ash	0.12	0.09
Total	<u>11.51 gms.</u>	<u>4.69 gms.</u>

The 'cream' from the Assam tea was red amber in colour, whilst the other was a muddy brown.

It is now of interest to examine the five groups of substances extracted from the three other teas, all of which happened to give thin liquors, lacking pungency and giving little 'cream' on cooling. As before, the figures represent gms. extracted from 100 gms. tea. In the analytical data given, no account is of course taken of the aroma or quality of the Ceylon tea, assets frequently of far greater value than liquoring qualities.

	<i>Ceylon tea gms.</i>	<i>Dooars tea gms.</i>	<i>Nyasaland tea gms.</i>
Extractable catechins . . .	9.3	7.7	7.8
Non-extractable catechins . . .	7.2	8.2	8.5
Caffeine	2.8	3.4	3.1
Gummy matter	13.2	13.3	13.9
Inorganic ash	2.8	3.9	3.1
Total	35.3 gms.	36.5 gms.	36.4 gms.

The Ceylon sample in question contains about two-thirds as much ethyl-acetate extractable catechins as is shown by the particular Assam sample dealt with first. When an infusion of the Ceylon tea was made with half as much leaf again as used for the Assam tea, it gave liquors comparable in colour, strength and pungency to the Assam liquor. This would appear to confirm that the desirable liquoring properties in a tea infusion are dependent on the concentration of the extractable catechins.

Parallel work on this aspect of the subject in Ceylon has shown that quality depends largely on the ethyl-acetate extractable fraction in tea (minus the caffeine), and also on the total water soluble material. Both these fractions increase during withering and then fall off gradually after rolling, as the period of fermentation increases or the temperature rises above about 80° F.

Work on the gummy matter in a tea infusion has shown it to contain many sugars, including glucose, fructose, sucrose, arabinose and ribose. There are also present amino-acids including aspartic and glutamic, and the substance named theanine, an N-ethyl amide of glutamic acid, first found in

green tea in Japan and later confirmed in tea in Assam. This occurs in far greater quantity than the other amino compounds and is the major component of the amino-acid fraction in tea leaf or made tea. Theanine may account for 1 to 2 per cent of the total dry matter in tea, and its greatest concentration is in the upper stem of the shoot. Pectins are present in the gummy-matter fraction.

The inorganic ash consists largely of potassium phosphate, together with sulphates and chlorides of potassium, calcium and magnesium.

Before leaving the subject of quality in a tea infusion some mention of 'quality' in its narrower sense must be made. Briskness, strength, pungency and bright colours appear to be due wholly or in the main to the lower polymers of the oxidised catechins. 'Quality' seems to be allied to briskness and to pungency and is connected with aroma, but the factors which comprise it will need definition. It has been suggested that theanine, mentioned above, may be a factor concerned in 'quality'.

In correlating chemical analyses with taste one difficulty arises from the fact that the palate does not respond in a simple manner to the contents of a tea infusion. Thus, as shown above with the Ceylon tea, a dilute infusion of extractable catechins may be described as lacking in quality whereas a stronger infusion may be said to have quality, using the term here in the general sense. The same holds with aroma, and in some cases, too strong an aroma may be distasteful whilst a touch of it is pleasant. The reverse also holds.

The Aroma of Tea

During the fermentation process in black tea manufacture, the so-called tea essential oil, responsible for the aroma of tea, is formed. All tea has an aroma, but some teas at certain seasons have special aromas which are highly valued and called flavours.

The sense of smell which detects aroma or flavour is located in the olfactory nerve in the nose, and the sensations there are distinct from those of taste which are detected on the tongue, or the feeling of pungency which is experienced on the gums.

From time to time, three volatile components have been

reported in tea, and considered responsible in part for aroma. These substances are phenyl-ethyl alcohol, citronellol and hexenol. When these substances have been added in small amounts to a tea infusion, the taster has detected a rawness, akin to briskness. The aromas of the three substances are different from that of tea and if they occur it must be in minute traces as part of the blend making up the total aroma.

The bulk of the volatile matter in tea consists of alcohols and aldehydes, and a number of different substances have been detected. There are considerable losses of volatile oil during the firing of tea.

It is of interest here to enumerate some of the more obvious aromas connected with tea. A field of tea has a very definite smell especially on a warm, humid day, when a marked, spicy, acrid aroma is present similar to that which makes up part of the smell of infused black tea.

Different bushes in the field have different aromas and leaves with a particular aroma have been detected by tea tasters as high-quality bushes. It would thus appear that, according to some tasters, aroma and 'quality', using the last term again in its restricted sense, are allied in some way.

Freshly plucked tea leaf has the same spicy smell as growing leaf, resembling that of ginger root or the concentrated smell of hay with the acrid part predominating. As withering proceeds, the leaf develops a marked fruity smell, as of apples. During the first ten minutes or so of rolling the fruity smell is accentuated and includes the smell of pears, the last being strong when under-withered leaf is rolled.

As the leaf ferments, the fruity smell fades and a nutty aroma, as of almonds, together with the basic spicy smell, become apparent. With flavoury teas the flower-like smell is also evident at this stage.

Freshly fired tea has a smell of burnt toast and also a caramel smell of burnt sugar. Dry tea leaf has a smell as of leather or tobacco.

The aroma of flavoury tea is that of flowers, at times of roses, together with the acrid tea smell. The cold infused leaf of such tea has the acrid and flowery smells combined, resembling geraniums or blackcurrants, both of which comparisons are often used by tea tasters.

Micro-organisms on Tea Leaf

Tea leaf in the field carries on its surface a large population of naturally occurring bacteria. During the withering, provided the surface of the leaf is dry, there is little increase in bacterial numbers, but if the leaf is wet they may increase greatly.

When leaf is rolled, there is an immediate drop in the numbers of micro-organisms, due to the antiseptic properties of oxidized polyphenols. Thereafter foreign bacteria, which are omnipresent, may infect the leaf and bring taints. On this account scrupulous cleanliness is very desirable in rollers, leaf trolleys and on fermenting surfaces.

During fifteen minutes firing all the bacteria are destroyed, but moulds have been known to persist even after apparently thorough drying.

Bacteria produce taints and even the maltiness and flatness in some teas are considered due to bacterial action. Bacterial risks seem to be greater in North-East India than in Ceylon or in Africa. In Ceylon it has been shown that leaf sterilized by mercuric chloride still ferments normally, and it is now concluded that bacteria, yeasts and fungi do not play an important part in black tea manufacture.

Tea Manufacture and Biochemical Change

It is now proposed to summarize briefly the chemical, physical and bacteriological changes occurring during the manufacture of black tea, and to consider the effect of time and temperature on such changes.

Withering

When the leaf withers physically, moisture is lost, and it is common for the weight of the leaf to be reduced by one-quarter in Assam and by one-third or more in Ceylon.

As withering proceeds, the loss of moisture takes place mainly from the leaves, and water is transferred from the bud and stalk to the leaves to maintain some sort of balance. The loss of moisture from the leaves is rapid during the first four to eight hours, after which it slows down over the next ten to twelve hours and the wither is said to even up. During the early period the leaves may contain only 50 to 60 per cent moisture,

the bud over 70 per cent and the stalk also in the bulk of the leaf at the end of eighteen hours the leaves and the leaf, although the about 66 and the stalk about 70 per cent. For period of about eighteen hours is desirable.

The rate of the physical wither depends on the mass of the leaf is spread on the withering space, on the humidity° F. above the temperature and the rate of air flow. With qualities in the pays to wither at 70° F. or even lower, but when quality-lykedly present the difference between a high temperature, 90° F. on a low one is less marked.

During the physical wither the permeability of the leaf increases. If withered leaf is steeped in water, a coloration with ferric (iron) chloride is obtained in a few minutes because the polyphenols have seeped out of the leaf into the water. Fresh leaf gives such a coloration only after several hours of steeping.

The period of the wither is important, quite apart from the question of evenness of the drying throughout the shoot or the development of permeability. Generally speaking, it has been recorded that as the time of wither increases from six to forty-two hours, colour and strength increase but briskness decreases. Quality improves up to thirty hours, then decreases rapidly. With a long wither, the harmful effects can be reduced by a short fermentation, but the reverse does not hold, and the shortcomings of a rapid wither cannot be put right by extending the fermentation period.

Over the withering period the leaf continues to respire and carbon dioxide is given off. As a result the total dry matter of the leaf may fall by perhaps 3 per cent. Thus 100 lb. fresh leaf containing 25 lb. solids may at the end of the wither contain only $24\frac{1}{4}$ lb. solids.

During withering the starch and soluble gums decrease and the sugars increase. The protein matter decreases slightly and amino-acids, which are soluble, are formed.

No change in the polyphenol content takes place during a correct wither, but their concentration in the cell sap is increased, as is also that of the proteins. These physical changes will affect the nature of the condensation of the polyphenols during fermentation and also their precipitation by leaf proteins.

The important conclusion has now been reached by scientists

manufacture that during a normal wither, occur in the leaf which materially affect the Tea leaf in the tea liquors. These changes, referred to many of naturally occurring as the 'chemical' wither, are more the surface of the time interval that elapses between plucking numbers, less than with the physical loss of moisture (the 'physical'). A tea taster describes a tea which is made from unwithered leaf as giving a 'brassy' liquor, denoting a raw-oxidized or harshness. With fine leaf, quality is lost or not fully enveloped unless the leaf is withered. When leaf is held over for eighteen hours but not physically withered, the tea is not quite as good as it would have been had both physical and chemical withers materialized.

Rolling and Fermentation

The changes undergone by the polyphenols due to their oxidation and condensation during fermentation, and the development of the tea aroma, have been referred to earlier.

In Assam it is recorded that different varieties of tea ferment at different rates, whilst the same bush produces leaf which ferments at different rates at different times of the year.

Oxygen is absorbed in fermentation and indeed, this is the essential part of the process. The enzyme plays its part in assisting the polyphenols to take up this oxygen. The rate of absorption is rapid at first but slows up after about three hours. Fermentation takes place much more rapidly in an atmosphere of oxygen than in air, a fact which is important if manufacture is to be speeded up and converted from a batch to a continuous progress. In this case the fermenting leaf would probably go to a moving band between the rolling machine and the dryer. Anything hastening oxidation would of course reduce the necessary length of the moving band. Tea fermented in oxygen has somewhat better quality than tea ordinarily fermented.

During fermentation heat is evolved, and in a roller taking 300 to 400 lb. leaf the temperature rise may be 10° to 15° F. above that of the air, if the leaf is lightly withered. With fully withered leaf, presumably because there is less water to absorb the heat evolved, temperature rises may be as much as 20° . Most of this rise is due to the heat of friction, but some is due to the heat of fermentation. When steamed leaf is rolled, in the

making of green tea, the temperature rise in the bulk of the leaf is more than half what it would be with live leaf, although the leaf has been killed and does not ferment.

Whilst the rolled leaf is spread on the fermenting space it heats up, and the rise in temperature within the mass of the leaf spread on a cement floor at $1\frac{1}{2}$ in. thick, may be $\frac{1}{2}^{\circ}$ F. above the air temperature. If the leaf is fermenting rapidly, as in the case of tobacco-cut tea, the rise in temperature is markedly greater. Differences in the thickness of spreading within reason do not affect the access of air to normally rolled leaf. Light and atmospheric humidity have no effect on the rate of oxygen uptake by fermenting leaf.

The effect of temperature on fermentation is complicated because an enzyme is concerned in the process. Normally the speed of a chemical change is doubled for each 18° F. rise in temperature, but the enzyme activity is reduced above 80° and accordingly, the rate of oxygen uptake above this temperature falls off. But the condensation of the polyphenols after oxidation is not dependent on the enzyme and this part of the reaction proceeds more rapidly as the temperature rises above 80° . The total result is a falling off in quality and strength at temperatures above 80° .

The best all-round air temperature for tea fermentation is from 60° to 80° . Experiments in Assam denote that from 60° to 80° , there is a steady increase in the strength of the liquor produced, but a falling off in quality if such be present in the leaf. From 80° to 100° , the strength decreases and quality is practically lost entirely as temperatures rise above 90° .

The tea juice first expressed from fresh or withered leaf has a pH value of about 5.4 but during fermentation the acidity increases and the pH may fall to about 4.4. This increase is due to the liberation of acids from the polyphenols. No change occurs in pH during firing.

In Assam it has been found that an initial charge of leaf in the roller of about 300 lb. and two half-hour rolls gives the best results. The damage done in the first roll is actually all that is needed for as much oxygen is absorbed when one roll is given as with more. Yet the twice-rolled leaf gives a stronger and more coloury infusion than leaf once-rolled, although the total extraction in one hour is the same from leaf rolled once or twice.

It is concluded that the main effect of the second roll is to wring out the leaf and to make the soluble matter more easily extractable. This aspect of rolling is reverted to later when the C.T.C. machine is described and discussed.

Firing

During firing the enzyme is inactivated, bacteria, yeasts and micro-organisms on the leaf are destroyed and moisture is removed from the leaf. Much of the aroma of the leaf is lost in firing and the liquoring qualities are inferior to those given by fermented but unfired leaf. The condensation of the oxidized polyphenols continues for some time after the leaf enters the dryer.

The physical aspects of firing tea leaf are the same as those governing the drying of other solid bodies in that the drying must not be too rapid at first, otherwise the body is case-hardened and moisture is entrapped within.

Ideal firing conditions have been worked out from the practical point of view with the aid of the tea taster. When the leaf first enters the dryer it should be met by an air blast with a temperature of 140° to 150° below the top tray of the dryer. When the tea is dry at the discharge it should be submitted to 180° to 200° , although in some cases where the leaf apparently contains gummy matter which 'takes the fire' well, as with Darjeeling second-flush teas, a temperature of 240° F. may produce good results, giving a burnt aroma which is pleasant and acceptable.

When the fermented leaf enters the tea dryer it is a 'wet' body and as such tends to take on the temperature of the wet bulb of the air blast. The air of the dryer which meets the incoming leaf on the top tray has dry and wet bulb temperatures of about $140^{\circ}/100^{\circ}$ F. respectively, and after passing through the leaf leaves the machine with dry and wet bulb temperatures about $125^{\circ}/100^{\circ}$. Passing downwards through the dryer the temperature of the air rapidly rises, being about 160° below the second tray, 175° below the third, 185° below the fourth, 195° below the fifth and 200° below the sixth tray. These temperatures hold with a six-tray dryer when the initial firing temperature is 200° . All the way through the dryer the wet bulb temperature of the air is about 100° F. at which it remains steady.

If a single fire is given, then the leaf should take twenty-five to thirty minutes to pass through the dryer, and at the end of sixteen to twenty minutes it will have reached the beginning of the fifth tray in a six-tray dryer and its moisture content will be 12 to 15 per cent. At this stage the leaf is crisp and it has become a hygroscopic body which can take on the temperature of the dry bulb of the air blast. Thus it is only over the last third of the drying period that the bulk of the leaf begins to get much hotter than 100° .

When the leaf is dried in a double operation, as in Assam, the first fire takes it to a state of crispness, at which it has just become a hygroscopic body. Accordingly, it is possible to use much higher initial temperatures in the first fire than is practicable when a single fire is given. The second fire temperature must not be high, however, and 180° gives the best results. Fully fired tea contains 1 to 3 per cent moisture.

There is still much to be learnt about the physics and the chemistry of the drying process.

CHAPTER VI

THE PHARMACOLOGY OF TEA

*The food value of tea—Caffeine—The polyphenols in tea—
The brewing of tea.*

AN infusion of black tea is used as a beverage primarily on account of the stimulant, caffeine, it contains. As a general rule, the teas most highly valued are those made from the finest leaves and these contain the most caffeine. Such leaves also contain the highest proportion of polyphenols which give rise to the tannin bodies responsible for briskness and strength, both valuable qualities in a black tea liquor.

The proportion of polyphenols in green tea is as great or greater than that in black tea, but these bodies are still in the original form in green tea, and have not had their tanning properties developed. The stimulus given by green tea is, as with black tea, due to caffeine which is more easily extractable from green than from black tea.

The immediate comforting effect which a cup of hot tea has on the system is due largely to the warmth it supplies, since the action of the caffeine is not apparent for some minutes after drinking.

The Food Value of Tea

In countries like England and Australia, where people are heavy tea drinkers, the food value of the tea beverage taken daily forms an appreciable fraction of the diet.

A black tea infusion contains, in addition to caffeine and oxidized polyphenols, small quantities of protein bodies and carbohydrates. Neither are, however, present in sufficient quantity to be of appreciable value in the normal diet of the average person. A cup of tea even when taken with milk contains only about 10 grains of proteins. This amount is small

when it is considered that the average man requires 1,300 grains protein each day, and usually consumes much more.

The actual calorific value of a cup of tea, containing 6 fluid oz. has been put at 4 calories, which may be compared with a similar cup of coffee which supplies 11 and a cup of milk which supplies about 107 calories. The calorie is used as a measure of energy turnover in animals, and an active man requires 2,500 to 3,000 calories a day, so that food yielding that amount of heat when burned must be provided to maintain that energy output. A cup of tea containing a tablespoon of milk (10 calories) and one lump of sugar (25 calories) yields about 40 calories. The average rate of tea drinking in the United Kingdom is six cups a day for adults, and these with milk and sugar supply 240 calories on the above reckoning. This is a useful proportion of the total calories required, although most of it comes from the sugar and milk, and not from the tea.

It has been claimed that certain green teas are rich in vitamin C. A study of green tea infusions however, has shown that the beverage does not contain a sufficient amount of vitamins to be of importance in the diet of the average person. The presence of riboflavin, a vitamin of the B group, has been reported in tea but since this is widely, perhaps universally, distributed in living organisms, its presence might be expected. It is considered that any vitamins in black tea as manufactured in India, Ceylon and Indonesia would be destroyed during the firing process in which the leaf is subjected to a blast of hot air.

The ash of tea is strongly alkaline and contains about 50 per cent potash, most of which enters the infusion. On this account the claim that the beverage can alleviate acidosis in the human system and reduce the tendency to gout may be justified. The amount of potash, reckoned as oxide of potassium, in a cup of tea is somewhat less than $\frac{1}{2}$ grain.

Certain Asiatic people, notably the Shans, consume fresh tea leaf and in so doing follow a rational course since they benefit from the nutritive properties of the leaf. In Tibet a kind of soup is made of tea.

It is now proposed to consider in some detail, from the point of view of pharmacology, the two most important constituents of a tea infusion, caffeine and the group of oxidized and condensed polyphenols, sometimes spoken of as tannin bodies.

Caffeine

Caffeine is used as a drug and its action on the human system is stated in the *British Pharmaceutical Codex*, edition 1949 to be as follows:

Caffeine acts on the central nervous system, on muscle, including cardiac muscle, and on the kidneys.

The action on the central nervous system is mainly on the higher centres and produces a condition of wakefulness and increased mental activity. The ability to interpret sensory impressions is increased, thought becomes clearer and more rapid, mental fatigue is relieved, and the reaction-time is shortened. With large doses of caffeine the action extends from the psychical areas to the motor area, the medulla and the cord, and the patient becomes at first restless, and later may show convulsive movements. Caffeine facilitates the performance of muscular work and actually increases the total work which can be performed by a muscle. It stimulates the respiratory centre and thus increases the rate and sometimes the depth of respiration. In man it usually has no effect on the pulse rate. Its stimulant action on the medullary vasomotor centre is usually overpowered by its peripheral vasodilator effect on the arterioles, hence the blood pressure either remains normal or falls below normal.

The diuretic effect of caffeine is usually ascribed to the dilation of the renal vessels, the flow of blood through the kidneys being increased and a larger number of glomeruli brought into operation. Caffeine increases the excretion not only of water but also of urinary solids such as urea, uric acid and salts, although in a smaller proportion, thus lowering the specific gravity of the urine.

Since caffeine is a respiratory stimulant, it is used as an antidote to narcotic poisons. It is used in the treatment of congestive heart failure and chronic nephritis and is of value in nervous headache and migraine. It is administered as powders or tablets, and is frequently prescribed with acetylsalicylic acid, codeine or phenacetin.

Dose: 0.3 to 0.6 gramme (5 to 10 grains).

This account represents considered British medical opinion and contains only such facts as are thought sufficiently established for publication.

The caffeine content of tea varies from 2 to 4 per cent with an average of $3\frac{1}{2}$ per cent. The annual tea consumption in

Great Britain is about 9 lb. per head, a quantity containing on the average 2,200 grains of caffeine. Assuming three-quarters of the caffeine is extracted when the tea is brewed, the annual consumption would be 1,650 grains (about $3\frac{3}{4}$ oz.). The average daily consumption in Great Britain may be thus $4\frac{1}{2}$ grains, although for drinkers of poorer quality tea it may well be not more than 3 to $3\frac{1}{2}$ grains.

A pound of good tea makes 200 cups of the beverage. Since this quantity of tea contains perhaps 245 grains of caffeine, of which 180 grains may be easily extracted, each cup of tea made from freshly infused leaf contains about 0.9 grains of the stimulant. A second brew yields an infusion which only contains about 0.3 grains per cup, and further brews are practically devoid of the stimulant.

Many experiments have been made on animals and human beings in the study of the effect of caffeine on heart action, blood pressure, muscular activity and so on, using doses ranging from 1 to 6 grains in the free state, not in a tea infusion. The general conclusions show that the effect on the motor processes is quickly realized and is transient, whilst on the mental processes it comes more slowly but is more persistent. No secondary reaction has been observed in any test, even with what is considered a big dose.

Two main factors seem to modify the influence of the caffeine, body weight and the presence of food in the stomach. In practically all tests, the influence varies inversely as the weight of the subject, and is most marked when taken on an empty stomach or without food substance. The effect of caffeine does not seem to be influenced by age, sex or previous caffeine habits.

The Polyphenols in Tea

As described in the previous chapter, the polyphenols as they occur in fresh tea leaf are not true tannins. When they are oxidized in the so-called fermentation process of black tea manufacture they take on tanning properties and thereby achieve the power of precipitating proteins to form insoluble substances. The group of polyphenols in tea leaf in their oxidized and condensed forms make the briskness, strength, colour and body of a tea infusion. They are responsible for the

taste of tea (as distinct from aroma) so much appreciated by drinkers of the beverage.

Tannins are a group of astringent substances of wide occurrence in plants, dissolved in the cell-sap, and are common in the bark of trees, unripe fruit, leaves and galls. Before the complex chemistry of the tannin bodies in plants had been studied, the term 'tannin' was used to denote the tannins in oak gall, and any mention of the word still calls to mind a substance of that type to the layman.

The term 'tannin' or *acidum tannicum* is used in pharmacopoeia to denote digallic acid. *Acidum tannicum* as the free acid is astringent to the gums, but in the stomach it combines with alkalies and albumen to form tannates whereby its astringent property is lost. As the tannates are digested the tannic acid is again liberated, and so the process is repeated till in the intestines, by coagulating proteins and diminishing secretions, constipation may result. *Acidum tannicum* is therefore used occasionally in diarrhoea. The dose is 0.3 to 0.6 gramme (5 to 10 grains).

For fifty years or so, starting about 1880, frequent attacks were made on tea as a beverage, usually based on the assumption that the tannin bodies in the infusion acted like *acidum tannicum*. Tea is so firmly established now as a common drink in so many countries, that any suggestion that its effect is harmful to the drinker carries little weight.

It is known in medicine that a total daily dose of 45 grains of the tannic acid of pharmacopoeia will completely constipate the average person in three days. In order to determine the effect of the tea tannin bodies in this respect, experiments were carried out at Tocklai, Assam, in 1930. Daily doses of 45 grains of the polyphenol mixture, extracted from fresh leaf in some cases and from black tea in others, were administered for three consecutive days to a number of male adults. In no case was constipation or indigestion registered. A dose of 45 grains of the tannin bodies given is equivalent to that contained in about eighteen cups of strong tea.

It is common experience that a cup of hot tea, especially early in the morning, has a slight laxative effect. This may result from the warmth of the liquid.

The probable action of the polyphenols in a tea infusion

during their passage through the alimentary tract may now be considered.

When fresh milk is added to a black tea infusion no precipitation of caseinogen, the protein of milk, occurs. If the milk is just 'on the turn', i.e. if it has developed sufficient acidity to bring the caseinogen to the point of coagulation and precipitation, oxidized tea polyphenols may complete the process. This accounts for the curdling of such milk when it is added to tea. The addition of milk to tea is in effect the addition of protein, and the result is that the astringent and acid properties of the polyphenols are allayed. If tea is drunk without milk, then an astringency or contraction of the membrane is experienced on the gums.

As tea passes from the mouth through the gullet, the oxidized polyphenols therein are still held by the caseinogen in the milk. When these compounds reach the stomach, the strong acid medium there, with a pH value of about 1.5 will curdle and precipitate them.

In the stomach, the caseinogen may be decomposed by the stomach juices and the polyphenols again liberated, to recombine with any available proteins or to exert astringency on the stomach membrane. When in due course the polyphenols reach the intestines, where the reaction is alkaline, any precipitated polyphenols will be dissolved and any compound with proteins will be decomposed and the liberated tannin dissolved. Such tannin might overcome local alkalinity and then exert its astringency, but it is difficult to figure how the two or three grains of oxidized and condensed polyphenols included in a cup of tea can produce any appreciable degree either of astringency or acidity at any stage during its passage through the alimentary tract.

The Brewing of Tea

Tea is best made with freshly drawn water which has just come to a vigorous boil. The prolonged boiling of water drives off the dissolved air and such water, until it is aerated again, has a characteristic which may be described as 'flat'. This property reappears in a tea infusion made with over-boiled water.

Tea should be infused for about five minutes, although the

smaller grades like Fannings and Dusts yield strong liquors in a shorter time. During the period of infusion the hotter the water is kept the more solid matter is extracted from the leaf, indeed some of the best attributes of black tea are only extracted by very hot water.

The amount of tea which should be used is governed largely by taste, but most tea drinkers have settled down to the empirical rule of adding one teaspoon for each person and infusing for about five minutes. Custom usually demands that one extra spoonful be added 'for the pot'. Another useful measure is the addition of one level spoonful of tea for each breakfast cup made.

Actually about 3 gms. tea per 150 ml. water are employed. Thus with a quart teapot, holding six tea cups or four breakfast cups, about $\frac{2}{3}$ oz. of tea is taken. At this rate the number of tea cups per pound of tea is 144. It is usual to serve hot water with tea which is added to the pot after some has been poured out. On this account the actual number of cups per pound is about 200. Unless tea is to be watered, less than $\frac{2}{3}$ oz. would be added to a quart teapot.

It is instructive to examine the percentage of the total caffeine, polyphenol products and soluble solids extracted under different conditions of brewing tea. In the table below, extraction figures are shown for tea infused five minutes and then watered, against those given by a long brew of thirty-three minutes.

<i>Infusion</i>	<i>Caffeine</i>	<i>Polyphenols</i>	<i>Soluble solids</i>
	%	%	%
1. Five minutes under cosy .	80	40	60
Second brew twenty minutes under cosy	20	20	25
2. Thirty-three minutes under cosy	100	60	85

It will be seen that one brew of thirty-three minutes extracts the same amount of matter as two brews, the first of five and the second of twenty minutes.

The second brew contains only a quarter of the caffeine in the first and is of less value as a stimulant to that extent. The second brew does not contain as many polyphenol products

as the first, although they may have more marked tannin qualities than those extracted by a short infusion.

The chemical action of milk on a tea infusion has already been discussed. The addition of sugar sweetens the infusion and lemon flavours it. So far as can be judged these substances have no other action on the infusion.

It is of interest to record that when an infusion is kept hot for a period of some hours, condensation of the polyphenols therein appears to go on, with a deterioration in quality. This probably accounts for the fact that tea kept hot in a thermos flask has not the same quality as when taken straight off the brew.

PART II

THE TEA COUNTRIES OF THE WORLD

CHAPTER VII

TEA IN CHINA

Historical and descriptive account of tea in China—The growing of China tea—The preparation of black tea in China—Green tea—Oolong teas—Scented teas—Brick and tablet tea—The tea markets of China—The classification of China teas—Tea in Formosa.

CHINA, the classic tea country, gave both the beverage and the word 'tea' to the world. Yet in spite of the fact that the tea bush has been cultivated and the leaf prepared in China for many centuries, very little accurate information about methods in this country is available and practically no scientific data.

The export trade in China tea was enormous in the latter part of the nineteenth century but, largely due to competition from India and Ceylon, it has now dwindled to a fraction of its former size. In the meantime the methods of the tea farmer appear to have undergone little change and in the years to come the domination of the world tea market by the product of China may be looked upon as an incident in the long centuries of tea farming in this country. .

On the other hand China, possessing all the advantages that hereditary aptitude can bestow in the preparation of tea, may modernize and rationalize her industry, as has been done in Japan, and again become an important factor in the export tea trade.

Historical and Descriptive Account of Tea in China

The origin of tea and its preparation has its roots in mythology. The introduction of tea is sometimes attributed, out of courtesy, to the Emperor Shin Nong who lived in the third millennium B.C. Another myth relates how Dharuma, a Buddhist monk who came to China in the fifth century A.D. was responsible for tea. This sage, during one of his prolonged periods of meditation, found that he was becoming drowsy. Seizing his offending eyelids he cut them off and cast them from

him, and where they fell a plant grew, the tea plant, from whose leaves can be prepared a drink which drives away sleep.

The first authentic account of tea was written by Lo-yu who lived about A.D. 780. He described the preparation of the leaf which, he says, must only be picked during certain moons, and not when it is raining or the sky cloudy. The leaf is manipulated in the hands and then dried and sealed. There are a thousand and ten thousand teas, adds Lo-yu.

Other early authors in describing the manipulation of the leaf speak of the use of steam. Steaming was carried out to extract the bitter water from the leaf, which was then rolled with the hands or in cloths, and dried sometimes in the sun or over a charcoal fire. Whether the earlier teas were powdered or pressed into cakes is not clear. In any case it is generally believed that the present method of preparation, in which each leaf is separate, was known at the time of Lo-yu.

In early times tea was idealized and Chinese poets wrote of the drink in the following strain:

The first cup moistens my lips and throat, the second cup breaks my loneliness, the third cup searches my barren entrails but to find therein some five thousand volumes of odd ideographs. The fourth cup raises a slight perspiration, all the wrong of life passes away through my pores. At the fifth cup I am purified, the sixth cup calls me to the realms of the immortals. The seventh cup—ah, but I could take no more. I only feel the breath of cool wind that rises in my sleeves. Where is Horaisan?¹ Let me ride on this sweet breeze and waft away thither.

The words *te*, *chia* and *cha* denote tea in various Chinese dialects, and in one or other of these forms has been transposed into most other languages.

The history of European trade in the Fast East is bound up with the tea trade. First came the Portuguese who settled in Macao, near Canton, in 1557. Next the Spanish took the Philippines and used Macao as a terminal port. The Dutch followed and settled in Jacatra in Java, renaming it Batavia in 1619. Then came the British who already had their headquarters in Surat and Madras, India and for this reason were late comers to China. At first they were turned away from Macao, the Dutch drove them from the East Indies and the

¹ The Chinese Elysium.

Siamese from Siam. Early in the eighteenth century however the Portuguese Empire was in decline, the Dutch were concentrating on Ceylon, Malacca and Batavia, and the way to China was open to the British. By 1715 the East India Company which for over 100 years had been entrusted by the Government with the monopoly of all British overseas trade with Asia, had firmly established itself at Canton as the principal European agency trading in China, until it could be said that the China trade was the exchange of commodities between Britain and China.

All the trade was done through Canton. Silk and tea were exported but there was always a trade balance against Britain which was levelled by payments of silver. In due course stocks of silver and bullion ran short and the adverse balance was made up by imports to China of opium grown in Behar, India. This trade began in 1800 and in due course led to the Opium War in 1840, as a result of which China was forced to abandon her policy of seclusion and open up to trade the ports of Canton, Amoy, Foochow, Ningpo and Shanghai, afterwards called the Treaty Ports. At the same time Hong Kong was ceded to the British Crown.

Tea was known in Europe in the middle of the sixteenth century, and the Dutch began importing it early in the seventeenth century. In Queen Anne's reign tea drinking in England became fashionable and rapidly spread. In 1703 the import into England was 100,000 lb. About a century later in 1805 it was $7\frac{1}{2}$ million lb. Tea was then a 'China' drink, and remained so for many years to come.

The growing importance of the tea trade in the nineteenth century was the origin both of the American bid for supremacy in the carrying trade and the successful reply of the British sailing ship designers with the series of famous tea clippers from *Challenger* to *Thermopylae* and *Cutty Sark* which, with the wool clippers, made the British merchant sailing vessels the fastest in the world. These clippers carried the early teas to London and the story of the race between *Taipeng* and *Ariel* from Foochow in 1866 with first crop teas has now become history.

In 1833 the East India Company lost its monopoly of the tea trade and began to look for new sources of supply, under their own control if possible. This led to the development of the tea

industry in India and Ceylon, as described in later chapters. It suffices here to denote how these new countries affected the China trade.

In the 'eighties, China still supplied the bulk of the tea consumed by the world. In 1886, the export figure reached its zenith of nearly 300 million lb. of which 170 million lb. came to Great Britain. In the same year India produced 90 million lb. and from then on rapidly moved into the lead of exporting countries. At that time Ceylon was putting out tea and the possibilities of the crop were realized in Java. With the change in the style of manufacture in the tea countries controlled by Europeans, a product different from China tea was put on the market. The general public gradually showed its approval of the new commodity, with the result that China tea was ousted and today is not a serious rival to that of India, Ceylon and Indonesia.

The China export includes black, green, brick and tablet tea. At the end of the century the total export of all types was still the considerable amount of 200 million lb. but by 1930 the figure had fallen to about 100 million lb. Thereafter the country was ravished by war and the exports tailed off to under 30 million lb.

Figures for exports from 1950 onwards are incomplete and do not include those to the U.S.S.R. or eastern Europe. Exports to other countries over this period are 25 million lb. or less, most of which is green tea.

The Chinese saw their markets disappearing with natural concern, but lack of modern knowledge, outdated methods and the absence of capital in the hands of the tea farmers, all contributed to the rapid disintegration of their tea trade, making it give way to organized competition. The organization of the export trade has also been open to criticism. Before the tea reaches the exporting firm it passes through numerous middlemen and pays many illegal taxes, with the result that the producer receives a very low price even for the finest tea, a fact which robs him of the incentive to produce the best.

The Growing of China Tea

Chinese writers state that tea was first discovered in the Vu-ye or Bohea mountains in the Fu-kien province. Others

say it was found in Sze-chuan province, in the Singlo Hill or green tea district of Kiang-nan.

Reliable figures regarding tea areas under cultivation or outturns are not available. The acreage has been put at 900,000 and internal consumption before 1936 at 500 to 600 million lb. per annum. In that year the exports were 82 million lb. which would bring the maximum total production to 682 million lb. In 1936 the production in the whole of India was 395 million lb. whilst in 1953 it had risen to 663 million lb. It is likely that today India is the world's biggest tea producer.

Although tea is farmed as far north as the provinces of Shantung, Ho-nan, Shen-si and Kan-su, over 95 per cent of the total is grown below this line in the twelve provinces of central and south China. Tea growing is a village industry and the product is harvested mainly for local consumption. Methods are primitive and the bushes are often grown on slopes unsuited to other crops. There is no set way of pruning. The leaf is plucked three or four times a year in the provinces of the Yang-tsi Valley and as many as eight times in the warmer provinces of the south.

The first picking takes place in the early spring, in April before the rains, and this yields the tenderest shoots with fine downy leaves producing the higher grades, largely Pekoe. The second picking is about mid-May and may continue into June. This picking is effected ten days after the spring rains, and the teas made from this leaf give strength. These two rounds are called spring pickings and they constitute just over half the crop from which the teas for export are selected.

The third picking takes place in August and makes up about 30 per cent of the harvest. This tea is of low quality. The balance of the crop is taken at the fourth picking, which produces the lowest grade of all.

Plucking starts on three-year-old bushes and when the plants are eight years old they are considered to give their best quality. Many farmers have perhaps only 100 bushes or so and cultivation takes on the character of gardening. A woman plucks about 20 lb. leaf in a day.

Every Chinese village has its own tea purchaser who buys the tea as soon as it is prepared and sends it to the tea centre of the district where it is fired, as necessary, to give it keeping

qualities. When enough tea has been collected at the centre it is sorted either mechanically or in hand sieves and finally fired in baskets as described later. The leaf is then bulked, again lightly fired and packed warm in chests ready for transport to Hankow or to whichever market serves the area.

The Preparation of Black Tea in China

The preparation of black tea is a process open to an endless number of variations and modifications. The literature on the subject is by no means plentiful, and many of the more recent accounts are largely based on observations made by Fortune, Ball and Jacobson during the first half of the nineteenth century.

Samuel Ball, in his account of the culture and manufacture of tea in China, published in London in 1848, summarizes the method of black tea manufacture as follows:

Place the leaves in a sieve,
Expose them to sun and air,
Toss them and turn them as hay,
Then place them in the shade till they give out fragrance,
Roll with the hands or feet,
Finally dry over a charcoal fire,
And you have a fair Congou tea.

Congou is a general term for certain China black teas, and is a word derived from the Chinese *koong-foo*, meaning the laborious or assiduous sort, more time and labour being expended on this than on other varieties.

The exposure to the sun and air is carried on till the shoot is so withered that the stalks can be bent without cracking. This period of exposure should only last for an hour or two and is not easily carried out in dull or rainy weather. The leaves are next lightly turned and manipulated till they become red at the edges and develop red spots.

The bruised leaves are now put in a cool place to ferment, a process which may last up to six hours, according to some writers, but one which is governed by the development of the aroma.

When fermentation has proceeded far enough it is stopped by throwing the leaves into a shallow iron pan or *kuo* which is

made very hot, almost to dull redness, by a wood fire. The temperature may or may not have an important bearing on the type of tea made. It is stated in some literature that in making the finest Souchongs the Chinese use red heat in the *kuo*.

The leaves, which crackle when thrown into the pan, are rapidly manipulated. The fragrance gives way to a vegetable smell, which later disappears and the fragrance returns. The leaves, now supple, are rolled on flat trays.

After some rolling the leaf may be replaced in the *kuo*, cooler than before, and given further heating. Alternate rolling and heating may take place several times.

The final drying of tea is done with great care. The process is called *poey* and is carried out on bamboo trays placed in tubular, waisted, open-ended baskets called *poey-long*. These baskets are about $2\frac{1}{2}$ ft. high and are placed over a small charcoal fire. The tray carrying the tea is placed in the waist of the basket and care is needed in firing, for if leaf falls through the tray into the fire the smoke arising may taint the tea.

After half an hour or so the tray is removed from the basket, the leaf turned and manipulated, and then the tray is replaced. This kind of drying and manipulation continues till the leaf is too crisp for further rolling. As drying proceeds the fire is damped down with rice husks or ash. The process is a very slow one and may last several hours, the last stages being executed over a very small fire with the top of the *poey-long* covered with a tray.

The teas are sent to central factories or *hongs* for final packing, where they are selected and made up into suitable parcels, *chops* or breaks of convenient size for selling to tea exporters.

Green Tea

In making green tea the sooner the leaf is roasted or steamed after plucking the better. As there must often be a lapse of time between the bringing in of the leaf and the heating process, it is necessary during this delay to keep the leaf cool. Exposure to the air before roasting is unnecessary, and to the sun, injurious. The *kuo* or iron pan used for roasting green tea is deeper than that used in black tea preparation and more leaf is added at a time. In roasting, the leaf becomes light yellowish-green in colour and there is a development of steam.

After roasting, the leaf is rolled in the same manner as in black tea preparation. First the leaves are placed on a flat tray and rolled into a ball. The ball is then shaken to pieces, and the leaves twisted about between the palms of the hand. They are then spread out and allowed to stand in a cool room. Another roasting follows, this time in a cooler pan and accompanied by much manipulation. When the leaves have become fairly dry and turned a dark olive green, almost black in colour, they are removed and cooled again. For the third time the leaf is roasted, this time in a still cooler pan and during this period it takes on a bluish tint or bloom.

The bloom on the leaf is the mark of quality, and at one time it was customary to add artificial colouring to the pan to give spurious quality to inferior tea.

An account of the preparation of green tea in Japan which follows in the next chapter describes the steaming process, which is there used in place of roasting.

Oolong Teas

Oolong teas derive their name from the Chinese word *ou-long*, signifying black dragon, which is applied to a variety of tea prepared in a certain manner, and having a small greenish-yellow leaf scattered through it. There are several kinds of Oolongs, e.g. Amoys, Foochows, Formosas, Ankis and Padre.

Oolong teas are semi-fermented. Their preparation resembles that of black tea, but the fermentation is carried less far. In the character of their liquors, Oolongs are intermediate between green and black teas. Some details of the preparation of Oolongs is given in a later section dealing with Formosa teas.

Scented Teas

Various flowers, preferably full blown, separated from their stalks, are used for the scenting of teas. The *Chloranthus inconspicuus*, *Jasaminum sambac*, *Olea fragrans* and *Gardenia florida* are commonly employed, but others are said to be eligible for the purpose, e.g. *Murraya exotica* and *Aglaia odorata*.

When green tea is scented it is taken from the basket (*poey*) fully fired, and whilst still warm poured into a chest to form a layer about 2 in. thick. A handful of flowers is strewn over the

tea, then another layer of tea is added, followed by more flowers and so on. A proportion of about 3 parts by weight of flowers to 100 parts tea is usual. The chest is kept for a day, when the mixture is put through the process of *poey* with the basket completely closed at the top. The heating lasts about two hours by which time the flowers are quite crisp. The flowers are then sifted out and the tea packed.

The tea thus prepared may be mixed with unscented tea in the proportion of one of scented to twenty of unscented. The whole is then slightly heated in an iron pan and when packed forms what was known in England in earlier days as Cowslip Hyson.

In scenting black tea a different method is used. The flowers are slowly dried in a basket (*poey-long*) and then powdered. The powder is mixed with the leaf during the last two dryings and rollings of the *poey* process or, more economic and usual, the powder is sprinkled over the leaf during the final process of *poey*.

Brick and Tablet Tea

The manufacture of brick tea was known in the Sung Dynasty (A.D. 966-1276) and brick tea was sent to the Emperor in golden boxes as tribute. Brick tea began to appear in Siberia in the seventeenth century.

When Foochow was opened to foreign trade, the Russians started to manufacture brick tea there by machinery. In 1882 the transference of the business to Hankow began and in the last years of normal conditions no less than 90 per cent of the brick tea exported was made here. The main business of manufacture and export was in the hands of Russian firms, although there were Chinese factories. British capital has been interested in this considerable undertaking.

The equipment of the Russian factories included all modern devices and machinery. For making black brick tea, leaf and dust were used, and much of the latter was at one time imported from Ceylon and India, up to 30 million lb. in one year.

For green tea bricks only leaf is used without any admixture of dust or stalk.

In the preparation of brick tea, adulteration is possible and common. Twigs, both of tea and other plants, wood, pine bark,

foreign leaves, sawdust and even soot are sometimes incorporated with the tea leaf. Much poor, coarse leaf is used in brick tea, and it is considered that brick generally represents about one-sixth the strength of an equal weight of good leaf tea.

The usual dimensions of a black brick are 8 by 12 in. and 1 in. thick. Green tea bricks are 7 by 12 in. or 8 by $5\frac{1}{4}$ in. Bricks weigh about $2\frac{1}{4}$ lb. each and are packed in baskets which take from thirty-six to 144 bricks, but the usual number is about eighty bricks in one packet.

Tablet teas are made in the same manner as brick teas, but only the finest dusts are used.

The Tea Markets of China

The chief markets of China have changed considerably over the past 250 years and reflect the history of European trade with the country. In the early days of the tea trade with Europe the Kwang-tung province, exporting from Canton, was the centre of the business. After the Treaty Ports were opened in 1840 the trade moved north to the Fu-kien province, with Foochow as the buying centre, touching its peak as a tea port in 1880. After this trade began to move to Hankow. Amoy, lying between Canton and Foochow, was at one time a tea port dealing with much of the Formosa trade. When that island became part of the Japanese Empire in 1894 the ports of Formosa were developed and Amoy suffered accordingly.

Before the World War I the cultivation of tea for export was concentrated in the five provinces of the Yang-tsi basin, Hu-peh, Hu-nan, Kiang-si, Anh-wei and Che-kiang, and in the Fu-kien province. At this time the total export was about 100 million lb. per annum mainly as green tea.

Hu-peh was the most important province producing black tea for export and the greatest tea mart in China was Hankow which dealt with four-fifths of the export black tea trade. The city, situated about 600 miles up the Yang-tsi from Shanghai, was opened to foreign trade in 1861 and is served by ocean-going steamers. The tea market opened about mid-May and lasted till the end of October, although the most active period finished in July. The British controlled the market till 1890, but then interest shifted to India and Ceylon and control

passed to Russian hands. By 1915 the export of brick tea alone from Hankow was 80 million lb.

With the collapse of the Russian market in 1918 the Hankow trade was paralysed and Shanghai became the tea centre, transshipping not only the black teas from the markets of Hankow and of Kuikiang, lower down the Yang-tsi, but also green teas from the Che-kiang province.

During the troubled years of the last two decades the export of tea from the ports has fallen severely, although there were signs of revival in 1946 which have since faded. In 1949, the Ministry of Commerce set up the China National Tea Corporation which controlled Government factories for processing tea, presumably purchased from villagers. In 1950 these factories dealt with 138 million lb. tea and with 182 million lb. in 1952. Possibly much of this tea is exported to the U.S.S.R. and the Soviet bloc countries in eastern Europe.

The Classification of China Teas

There is no standard classification of China teas. In the broadest sense teas may be divided into two groups, leaf and compressed. Compressed tea may be brick, tablet or ball form. Both leaf and compressed tea may be black or green. Teas may be classified according to the method of preparation, to the time the leaf was picked and the age of the bush from which it was picked. Each kind of tea also has a number of grades.

In order to avoid the complications arising from the above systems, exporters of China tea have established a method of classification of their own to answer the practical needs of the trade, based partly on the source of the tea and partly on the method of preparation. The first attempt to classify China teas for export was made by J. H. Wade, a noted British authority on tea, who distinguished twenty-two classes of black and six of green teas. Torgasheff, in a later classification which is more discerning, distinguished sixty-four classes of black and forty-eight of green teas.

Teas exported do not always keep their original Chinese names and are often known by quite different appellations. The following are some of the well-known marks of both black and green China teas. From the Anh-wei province: Keemuns.

From the Kiang-si province: Ningchows, Kut Oans and Kien Tucks. From the Hu-nan province: Onfars and Shan Tams. From the Hu-peh province: Ichangs. From the Fu-kien province: Pan Yongs, Paklums, Chingwos, Paklings, Saryunes, Souchongs, Soomoos, Suey Kuts and Lapsangs. These are all black teas. Well-known green teas are Moyunes and Tienkais from the Anh-wei province, and Hoochows and Pingsueys from the Che-kiang province.

Most of the black teas exported from China are known as Congous, prepared in the manner described earlier in this chapter. These teas are sub-divided into North China Congous or Monings (black leaf) from Hankow, and South China Congous (red leaf) from Foochow.

Souchong teas are made in the Congou manner but from coarser leaf. The term is derived from the Chinese *siao-chung*, meaning small sort. A kind of tea known as Padre Souchong is made by the Buddhist monks in the Vy-ue Shan (Wu-I-Shan) or Bohea mountains. Capar is a black tea twisted into small balls.

The term Bohea is applied to some teas, and was the name first given to the finest black teas but is now used to designate the lowest type, made from the last plucking of the season.

Pekoe, Orange Pekoe and Flowery Pekoe are three classes of tea whose names partly indicate the fineness of the leaf constituting the class. The term Pekoe is derived from the Chinese *pek-ho*, denoting white hair or down, and refers to the fine hair seen on the buds and younger leaves. When fermented tea juice is smeared on these hairs they appear yellow, orange or golden in colour. Flowery Pekoe is made from the tenderest buds which appear in the spring and is unfermented. This class of tea consists mainly of silvery flower or 'tip'.

Mention has already been made of Oolong teas which constitute a separate group. They are further classified according to the district in which they are made.

Green teas are classified according to the way the leaf is rolled and its size, and further by the place of origin. The chief grades of green tea are Gunpowder, Young Hyson, Hyson, and Imperial, placed in descending order of fineness and closeness of twist. Gunpowder is made from the tenderest buds rolled into balls ranging from Pinhead to Pea Leaf, the smaller the ball the

more expensive the tea. Other grades are Waisan, Sowmee and Hyson Skin. The Chinese name for Gunpowder is *Choo-cha* or Pearl tea, a name indicating its form. The term Young Hyson is derived from the Chinese *wu-he-t sien*, meaning early spring and indicates the plucking period. The true Imperial, known in China as Flower tea, is not exported.

The term Twankay is sometimes used to denote a grade of green tea. This term is derived from the Chinese *Taung* and *Kei*, the names of two rivers in the Anh-wei and Che-kiang provinces and was originally used to designate the teas from this district.

The Chinese themselves place teas into five groups, red, green, yellow, red brick and green brick. Each group is subdivided into four grades, rough, tender, old and new. Thus there are twenty kinds which are again divided into well-made and ill-made teas. To this classification is added the name of the province and the district of origin, with the result that the complete classification consists of several thousand grades. Yellow tea is not exported. It is known as Mandarin tea and before the days of the Republic was prepared in certain places for persons of rank at the Imperial court. This is a very fine tea made from the youngest buds.

Tea in Formosa

Formosa or Taiwan is an island roughly oval in shape, about 220 miles long and ninety miles at its broadest. It lies across the Tropic of Cancer ninety miles from the coast of the Fu-kien province of China. A range of mountains runs down the length of the island, north and south, leaving a broad plain on the western side.

The aborigines of Formosa are of Malayan stock, now confined largely to the mountains of the centre and the east. The Chinese came to the island late in history, but they form the bulk of the population of the lower lands. After the Sino-Japanese War, Formosa was ceded to Japan in 1894 and since that date the resources of the island have been rapidly developed. In 1945 the island passed back to China.

Tea was brought to Formosa by the Chinese and the Oolong process of tea preparation was introduced by the settlers from the Fu-kien province. The tea is planted in the north end of

the island in the prefectures of Taihoku and Shinchiku and, as in China and Japan, it is mainly in small patches, run by individual farmers. At present about 105,000 acres are under tea and the annual production is 26 million lb. of which over 20 million lb. are exported.

The variety of tea in Formosa is China, but several sub-varieties within the type are defined and recognized, and the Oolong flavour is supposed to be marked in one particular strain. The tea is propagated by layers, for it is considered that plants grown from seed do not give the unique flavour for which Formosa Oolongs are bought.

Since 1930 Assam strains of plants have been introduced and modern type factories equipped for making black tea, with rollers and dryers as used in India and Ceylon, have been put into use by Japanese firms. In 1931 the export of black tea was only $1\frac{1}{4}$ million lb. but by 1939 it had risen to almost 10 million lb. In that year the rest of the 25 million lb. exported included $5\frac{1}{2}$ million lb. Oolong and over $8\frac{1}{2}$ million lb. Pouchong. The last is a black, scented tea.

The preparation of Oolong tea is as follows. As in China and Japan, tea for export undergoes two processes, the first on the garden and the second at a central factory. In preparing Formosa Oolongs the leaf is placed in the sun to wither for an hour or so, and then in the shade to cool. Tossing and light manipulation follow and fermentation is thus induced, turning the leaves red and developing a fragrance. When the fermentation has reached a certain stage, short of that aimed at in black tea manufacture, the process is stopped by roasting the leaves in a pan. Rolling follows, alternated by roasting and finally the leaves are dried in baskets. The village product is packed in bags and sent to Daitotei, a part of the town of Taihoku, where the tea market and re-firing factories are situated, and here it is sorted, re-fired and packed by the exporters.

The Japanese established an experimental station at Heichin, Shincheka-Shu during their occupation of the island.

CHAPTER VIII

TEA IN JAPAN

*Organization of the industry—The tea crop in Japan—
Pests and diseases—The preparation of green tea—Re-firing
tea for export—Tea ceremony in Japan.*

ALTHOUGH Japan is the first industrial nation in Asia it still has two considerable agricultural export items, the first of which is silk and the second tea. Tea and mulberry cultivation (the leaf is fed to the silkworm) are twin industries, although whilst the area of the latter has expanded, that under tea has steadily declined over the past sixty years from 150,000 acres to 80,000 acres today. However about 1890 the annual tea crop was 66 million lb. but today, from a little over half the then acreage, it is 100 million lb. This gives an indication of the advance made in tea culture during this century.

Tea culture in Japan has a long history, dating from about A.D. 800 when the plant was introduced from China. For the first 500 years tea was regarded as a medicine rather than a beverage, and for over 1,000 years only green tea was produced. In 1835 a high grade green tea Gyokuro, described later, was increasingly produced, whilst in 1935 black tea production was developed of which over 14 million lb. was made in 1937, the peak year. Manufacture of this commodity is now going ahead again.

The Dutch began to take tea from Japan in 1610 but European contacts were thereafter discontinued until 1859. Then export trade started again with Britain as the chief customer for tea, taking over 22 million lb. in 1864. After that the tea trade with Britain declined and shifted to the United States.

In 1937, of the total production of 119 million lb. Japan exported a record amount of over 54 million lb. tea, 40 million lb. green and 14 million lb. black tea. Of this total, over 20 million lb. went to the U.S.A. and Canada and 11 million lb.

each to U.S.S.R. and Great Britain. The black teas were well thought of in London.

A common size for a tea garden in Japan is $\frac{1}{4}$ acre and the total present area of 80,000 acres may be farmed by more than 1 million growers. Over half the outturn is produced in the Shizuoka prefecture, and the city of that name is the centre of the industry. The second district is Kyoto, with the neighbouring prefectures of Shiga, Miye and Nara. Gyokuro tea is made in the Kyoto area. The only other prefecture of importance as a tea producer is that of Kumamoto on the island of Kyushu.

Organization of the Industry

Unlike the tea industry in China, that in Japan is well organized. This is partly due to the fact that the main tea areas are compact and generally in country which is highly developed, and partly to the genius of the people. The Central Tea Association was formed in Tokio in 1883 under Government guidance, and since then Prefectural and District Associations have been formed.

The object of the Central Association is to prevent the sale of inferior tea, to unify packing and to advertise Japanese tea abroad. The district branches deal with local affairs. Before tea can be exported it is officially examined for dust, moisture content and colour, whilst chemical tests are applied with regard to artificial colouring matter. The tea must pass the grading fixed for the year, which varies to reflect seasonal differences and other factors. Membership of these associations is compulsory for tea farmers.

In the city of Shizuoka, where the tea for export is re-fired and packed, there is an Association of Tea Firers. Shizuoka is the mart for tea and buyers from abroad have their establishments there as they do in other tea countries.

In Japan research on tea problems, both practical and academic, is well catered for. The National Tea Experimental Station at Kanaya was established in 1905. Since then many other district stations have been opened and in 1948 there were no less than fourteen, employing about 140 technical personnel on a total of 225 acres of land under trials.

In addition, three national tea seed farms were established

in 1947, the object of which is to produce pure seed for planting so that the present mixed stand can be replaced by improved lines of uniform quality. The Yabukita variety, isolated in 1887, is still being grown and also Nara No. 59 which has a genetic purity of 80 per cent. These seed farms are located at least one mile from the nearest tea plantation.

Twelve of the stations have tea breeding projects and six have propagation projects. Two Assam-China hybrids suitable for black tea manufacture are in commercial production. Eleven stations are studying manufacture, and all the other aspects of tea culture are under study at several stations. The standard of scientific work in Japan is very high indeed.

The Tea Crop in Japan

In Chapter IV, dealing with the culture of tea in general, mention was made of methods in Japan and there is now little to add. Yet certain points of interest to planters in India, Ceylon and Africa remain to be made.

Thus in North-East India the average crop between 1890 and 1900 was about 340 lb. per acre, and over the same period in Japan it was 440 lb. At present the crop in North-East India has risen to about 850 lb. per acre whilst that in Japan averages 1,200 lb. with a banner year in 1942 when the yield averaged 1,500 lb. per acre. Many individual estates in Assam and Bengal make 1,500 lb. tea per acre, but the average falls seriously below that figure.

The striking increase in Japanese crops has come from improved cultural methods and enormous doses of fertilizers. As an example of the latter, the amounts recommended in pounds per acre in the Shizuoka prefecture over three applications in the year are as follows:

<i>Date of Application</i>	<i>N</i> <i>lb.</i>	<i>P</i> <i>lb.</i>	<i>K</i> <i>lb.</i>	<i>Picking</i>
March 1-20 . . .	96	15	12	First, in May
June 1-10 . . .	96	15	12	Second, in July
September 1-20 . .	195	96	165	Third, in August
Total per acre	387	126	189	

The nitrogen is given as soya-bean and rape-seed cake, sulphate of ammonia and mulching grass. Superphosphates and potassium sulphate make up the bulk of the minerals. About 100 lb. of the nitrogen is given as sulphate of ammonia.

Harvesting is carried out three or four times a year, the shoot consisting of three to five leaves and the leaf-bud. The first picking in May, which can extend over forty or fifty days, produces the best tea. The second picking in June can extend over twenty or thirty days, and this makes good drinking tea. Both first and second pickings are made into tea known as Sencha. The third picking in August may extend over ten to fifteen days, and this is a mixture of new and old leaves, producing a poor tea known as Bancha. The third picking could actually make better tea than the second of Sencha, but for the inclusion of old leaf. In manufacture, Bancha is usually steamed and dried without rolling, differing in this last omission from Sencha and Gyokuro.

The fourth picking is taken in September and October and the harvesting period may extend over ten days. This tea, called Yoban-cha, is poor. This picking is not always made, for experiment has shown that four pickings often give less crop than three, over a number of seasons.

In 1937, when the maximum black tea outturn was made, the year's crop comprised the following:

	<i>million lb.</i>
Uji tea (Gyokuro)	0.68
Sencha	84.45
Bancha	22.35
Black tea	10.20
Total	117.68 million lb.

The harvest grown from good areas may average 4,000 lb. tea per acre and 2,8000 lb. yields are common. For the past fifty years or so, hand plucking has been superseded by plucking with light shears. By hand a woman can harvest 25 to 30 lb. leaf a day, but with shears 200 to 250 lb. may be gathered by a woman and 300 lb. by a man.

The ease of plucking will be appreciated when it is understood that the tea bush in Japan resembles a box hedge with a continuous flush from the crown to the soil.

Pests and Diseases

More than 100 species of insects are reported attacking tea in Japan. The four most harmful in order of importance are the smaller tea tortrix, *Adoxophyes privatana* the green fly, *Chlorita flavescens* the tea cochlid, *Phrixolepia sericea* and the tea tortrix, *Homona coffearia*. The first and last of these insects are usually found together. The tea cochlid is the only species of the four restricted to Japan, the others being found in China, India and Ceylon. The insecticides in general use by Japanese tea growers are pyrethrum products, nicotine sulphate and other tobacco products and derris root.

Forty-three fungus diseases have been listed, of which eight are considered to be of major importance. These include Brown blight, Blister blight and Rosellinia root disease. Bordeaux mixture is employed, and groups of farmers make up solutions and use them together. Much confidence is, however, placed in the use of fertilizers for disease control.

The Preparation of Green Tea

Both hand and machine processes are employed in the making of Japan green tea. In the hand process about 1 lb. of leaf is steamed at a time by placing it in a cylinder with a bottom of bamboo matting, and holding it over a vessel of boiling water. The steaming lasts for three to five minutes, after which the leaf is cooled as quickly as possible. The rest of the preparation consists of rolling the leaf on a warm surface till it is too dry for further manipulation.

The rolling table consists of a shallow wooden tray, about 6 ft. long and 3 ft. wide, the bottom of which is composed of paper three layers thick. Just under the paper is an iron plate, not near enough to rob the paper of its elasticity. The plate is warmed by a charcoal fire banked with the ash of rice straw, which heats the paper to as high as 240° F. and sometimes higher, although at 350° F. the paper begins to char.

The rolling is divided into four periods. During the first, the moisture content of the leaf is reduced from about 76 to 68 per cent. In the second it is reduced to 50 per cent. After this the tea maker rests, the holes in the paper are mended and the

leaf allowed to cool. In the third period of rolling the moisture is reduced to 30 per cent and in the last to about 17 per cent, when the leaf is too crisp for further manipulation. The whole rolling period covers three hours. The final drying is done on paper trays over a charcoal fire with an air current at 160 to 180° F. The best moisture content for export tea is 4 per cent, although for home consumption the leaf is dried to 10 per cent.

Machine manufacture follows the hand process as far as possible and there are four different machines, each of which attempts to duplicate the hand manipulation. The steaming machine is more elaborate than the hand preparation and deals with perhaps 5 lb. leaf per minute. The first rolling machine shakes out the leaf with springy, fork-like instruments working in a blast of hot air, reducing the moisture content of the leaf to 60 per cent. The second machine resembles a tea roller as used in India and Ceylon: it rolls but does not dry the leaf at all. The third machine tosses the leaf about in a warm air blast and dries it to about 28 per cent moisture. The last machine is a long corrugated trough which keeps the leaves end-on and rolls them with a wooden plunger. The bottom of the trough is heated so that the moisture content is reduced to about 10 per cent.

Tea factories in Japan are small and only deal with a few thousand pounds of leaf a day. They are practically all run by electricity. Many small growers sell leaf to factories.

The Uji teas are the finest produced in Japan and the best known is *Gyokuro*, the pearl dew tea. In order to produce this tea the bushes are covered with artificial shade, put up about three weeks before plucking, composed of grass and rice straw supported on bamboos at a height of 6 ft. As soon as the first picking is complete the shading is removed because it is injurious to the health of the bush. The leaf is prepared with great care after the manner described above.

Another tea produced in limited quantities is *Ten-cha* or milled tea, made from carefully selected leaves which are steamed and, after drying, ground into a fine powder. The tea itself is made by whipping the powder into a thick, creamy liquid. Neither *Gyokuro* nor *Ten-cha* are exported and like *Bancha* are consumed almost entirely in Japan.

Re-firing Tea for Export

Most of the tea for export is bought in the districts and then taken to Shizuoka for re-firing. This tea is Sencha, made from the first and second pluckings.

Re-firing takes place in iron pans in which the leaf is stirred mechanically, first in a hot pan then in a cold one. This process of rubbing, which may continue for an hour or so, gives lustre to the leaf and produces a whitish appearance. These teas have broken leaf and are called pan-fired.

At one time some teas were basket fired for export, as in the *poey-long* China process, and whole shoots, well twisted, were retained. Such teas were called basket-fired, or 'pine needles' or 'spiders' legs' in the American market.

Natural leaf teas are those made uniform by cutting and sifting. These teas are not rubbed as are the pan-fired teas, and they have replaced the former basket-fired teas in the export market.

There are many ways of classifying Japan teas, depending on the season of harvest, process of manufacture and locality of production, whilst grades within each type are based on colour, size and roll of leaf, and so on.

Tea Ceremony in Japan

In Japan, tea making and tea drinking often take on a deep significance which is almost religious. Okakura Kakuzo in *The Book of Tea* writes on the subject as follows.

Tea began as a medicine and grew into a beverage. In China in the eighth century it entered the realm of poetry as one of the polite amusements. The fifteenth century saw Japan ennoble it into a religion of aestheticism—Teaism. Teaism is a cult founded on the adoration of the beautiful among the sordid facts of everyday existence.

In China, tea passed through several periods which may be roughly divided into three stages, the cake-tea which was boiled, the powdered-tea which was whipped and the leaf-tea which was steeped. Japan closely followed Chinese civilization and knew tea in all three stages. Tea is mentioned in Japanese history as early as 729, and in 801 plants were brought to Japan

and grown at Yeisan and later, with greater success, at Uji. The use of steeped tea of the later China is comparatively recent in Japan, although now it has replaced powdered-tea which is only used on ceremonial occasions, but still regarded as the tea of teas.

When teaism was in its prime the tea room was the most important building, set apart from the house in a garden tastefully planted with shrubs.

The guests wash their hands before entering and leave their shoes and swords outside. They then enter the tea room before their host who kneels at the door. The guests in turn kneel before the *Tokonoma*, which consists of a low shelf let into the wall, a kind of altar which forms the nucleus of the room. On the wall is a *Kakenomo* or hanging picture, which rolls up like a map when not in use. The subject of the picture is something simple and austere and below it flowers may be arranged.

The host brings in the tea-making utensils and sets everything ready with much ceremony. When this is finished the guests retire and the host may arrange some fresh decoration for the *Tokonoma*.

When the water boils the guests are recalled by means of a gong, and food and *saké* are placed before them. Finally the powdered-tea is taken from its silken bag and placed in the tea bowl. On it is poured hot, but not boiling, water. The mixture is frothed with a whisk and then passed to the chief guest who drinks it ceremoniously with a loud, sucking noise. The bowl is then passed on and others drink in turn. When the ceremony is finished the guests depart.

The greatest master of tea ceremony was Rikiu who lived in the sixteenth century under the patronage of Taiko-Hideyoshi. The enemies of Rikiu accused him of treason towards his patron and the tea-master was condemned to death, but was granted the honour of dying by his own hand.

The last tea of Rikiu is described in *The Book of Tea* as follows.

On the day destined for his self-immolation, Rikiu invited his chief disciples to a last tea ceremony. Mournfully at the appointed time the guests met at the portico. As they look into the garden path the trees seem to shudder, and in the rustling of their leaves are heard the whispers of homeless ghosts. Like solemn sentinels before the gates of Hades stand the grey stone lanterns.

A wave of rare incense is wafted from the tea room, it is the summons which bids the guests to enter.

One by one they advance and take their places. In the *Tokonoma* hangs a wonderful writing by an ancient monk dealing with the evanescence of all earthly things. The singing kettle as it boils over the brazier sounds like some cicada pouring forth his woes to departing summer. Soon the host enters the room. Each in turn is served with tea, and each in turn silently drains his cup, the host last of all.

According to established etiquette the chief guest now asks permission to examine the tea equipage. Rikiu places the various articles before them, and after they have expressed admiration of their beauty he presents one of them to each of the assembled company as a souvenir. The bowl alone he keeps. 'Never again shall this cup, polluted by the lips of misfortune, be used by man.' He speaks and breaks the vessel into fragments.

The ceremony is over. The guests, with difficulty restraining their tears, take their last farewell and leave the room. One only, the nearest and dearest, is requested to remain and witness the end. Rikiu removes his tea gown and carefully folds it upon a mat, thereby disclosing the immaculate white death robe which it has hitherto concealed. Tenderly he gazes on the blade of the fatal dagger, and thus addresses it,

Welcome to thee, O sword of eternity.
Through Buddha and Dharuma alike
Thou has cleft thy way.

With a smile upon his face Rikiu passed forth into the unknown.

CHAPTER IX

NORTH-EAST INDIA AND THE TEA INDUSTRY

Geography and geology—Climate—Soils—Peoples—Communications—The beginning of tea in India—Organization of the industry—Statistics.

OUTSIDE China and Japan, it may be said that tea growing took its rise in the Brahmaputra Valley of Assam about 1840, spreading thence to Sylhet, Darjeeling, the Terai and the Dooars, thereby turning a primitive backwater of India into a highly developed and prosperous area. The tea districts are included in a triangle, roughly equilateral, the corners of which are Darjeeling, Sadiya and Chittagong. The sides of the triangle are about 400 miles in length. The whole area is spoken of in the tea industry as North-East India, distinguishing it from South India, where a second highly successful branch has been developed, and from North India, where small areas are planted at Ranchi, Dehra Dun and the Kangra Valley, none of which has advanced to any great extent.

Geography and Geology

The tea areas of North-East India lie in and around two great broad valleys, those of the Brahmaputra and its tributary the Surma. Practically all the tea is planted either on the flat land in the valleys or on the lowest foot-hills and only in the Darjeeling district are the estates actually situated in the mountains.

The Brahmaputra Valley is formed by the Himalayas on the north and the Barail Range on the south, the latter including the Patkoi Range, spoken of as the Naga Hills, and the Shillong Plateau. The Surma Valley is formed by the Shillong Plateau on the north and the Lushai and Chittagong hills in the east

and south-east. Both valleys open to the plains of Bengal on the west.

The Shillong Plateau, comprising the Garo Hills, the Khasia and Jaintia Hills and the Mikir Hills, is the starting point of the geological history of North-East India. The core of this land mass is of ancient gneiss, similar to that forming the Indian Peninsula. In early geological times the Shillong Plateau was partly surrounded by sea and the country now occupied by the Brahmaputra and the Surma valleys was low lying land between two oceans, successively raised and submerged so that at one time it carried forest and at another was depressed and covered by great depths of silt. The remains of this vegetation are now the coal measures of Assam, and the silt deposits can be seen as the Cherra sandstones on the Shillong Plateau.

At the end of the Cretaceous period in geology, a new era opened and widespread changes in the earth's surface began. Tibet, formerly below the sea, was uplifted and the gravel washed from it and deposited to form what is now Burma. Later, the Himalayas and the Naga Hills or Patkoi Range came into being.

The original gneiss of the Shillong Plateau is overlain by great depths of alluvium, although it crops up at Bishnanth, Silghat and Tezpur, and there is evidence of it even in the Dooars. Sediment from the crystalline rocks of the Himalayas forms the Red Banks of the Dooars which join the more recent alluvium of the plains.

The Naga Hills, the North Cachar Hills and the Lushai Hills are composed of Tertiary Sandstones which were gently uplifted from the sea about the time when the crystalline rocks of the Himalayas were being extruded.

The tea districts fall into four areas, the Brahmaputra Valley, the Surma Valley, the Dooars and the Terai, and the Darjeeling district. The Surma Valley comprises the districts of Cachar and Sylhet, the former in the Assam province and the latter in Eastern Pakistan. The Dooars, the Terai and Darjeeling are in Bengal, the Brahmaputra Valley in Assam.

Although the Brahmaputra Valley is surrounded by high mountains, almost the whole area is flat, level plain. Sadiya, near the head of the valley, has an altitude of only 440 ft. above sea-level, Dibrugarh 340 ft. and Gauhati 163 ft. The Himalayas

on the north rise abruptly from the plains to a height well above the snow line which is about 16,000 ft. in these latitudes. The Naga Hills on the south average only 4,000 ft. in height but reach 9,000 ft. in places.

The salient feature of the valley is the Brahmaputra, which is the Tsangpo of Tibet, and enters the plains of Assam by way of a gorge as the river called the Dihang. When it reaches the plains the Brahmaputra runs between sandy banks in a wide strath, forming divergent channels which later rejoin the main stream. The water is heavily laden with silt, although the fall being greater than 6 in. to the mile, much of the finer sediment is carried on to be deposited in lower Bengal. The smallest obstruction in the river is liable to form an almond-shaped bank which, with the next flood, may be entirely deleted or grow to form a *chur* or island.

Dibrugarh is on a sandy bank of the river and is periodically in danger of erosion. The only other towns of Assam which are actually on the banks are Tezpur, Gauhati and Dhubri, the last near the great angle where the river turns sharply to the south. Apart from the towns mentioned, the river meanders through a maze of sandbanks, sometimes thatch-covered. Old channels are often marked by a line of cotton trees. In the monsoon the river resembles a slow-moving lake, in parts as wide as five miles from bank to bank. Villages and tea gardens are usually remote from the river.

At one time the Brahmaputra flowed into the Bay of Bengal by its own channel, with the Surma river as a tributary near its mouth. The latter river, swollen early in the monsoon by torrential rain falling on the bare southern face of the Shillong Plateau, occupies what was the lower channel of the Big river early in the season. The Brahmaputra receives its flood from the jungle-covered hills in Assam which dole out the water gradually and, as a result, this river rises about three weeks later than the Surma. Formerly the Brahmaputra flowed near Mymensingh, but year by year it was held up by the Surma, and each year it deposited silt in its own course on this account, and eventually ran along an aqueduct of its own formation. Finally the flow of the Brahmaputra, stemmed by the Surma floods and encompassed by its own sandbanks, left its course and ran across country to join the

Ganges at Goalundo. The old course is now marked by a string of swamps and the Surma has sole possession of the lower course of what was formerly the Brahmaputra. This is one of the most interesting cases of what is known to geographers as river piracy.

Near the Brahmaputra is a belt of country from three to seven miles wide which is annually flooded. This is covered with high reed jungle interspersed with swamps. There is little cultivation in this tract except that of summer rice followed by pulse or mustard. The marshes or sandy *churs* left by the river form grazing land for buffaloes.

Away from this low-lying tract the valley is mainly occupied by village cultivation or by tea. The latter is put out on *bams* or banks which stand a few feet above the rice land, and on the lowest slopes of the Naga Hills on the south and the Himalayas on the north bank. The hills themselves are clad in heavy jungle except where this is under *jhum* cultivation by the hill tribes. This type of cultivation consists of cutting the jungle and growing a crop on the hillside for a year or two, after which much of the soil is lost by erosion and the land is then deserted.

Most of the tea in the Brahmaputra or Assam valley is put out in the Lakhimpur, Sibsagar and Darrang districts, the last lying on the north bank of the Big river. The table below shows the acreages and crops of the various districts in this valley in 1952, together with average crops per acre in that year.

<i>District</i>	<i>Acreage</i>	<i>Crop</i> <i>million lb.</i>	<i>Yield per acre</i> <i>lb. tea</i>
Lakhimpur	116,000	119.4	1,046
Sibsagar .	106,000	83.1	787
Nowgong .	12,700	10.5	829
Darrang .	63,000	63.8	1,023
Kamrup .	4,400	2.4	597
Goalpara .	3,700	3.3	973
Total	305,800 acres	282.5 mil. lb.	923 lb. average

Cachar, which is in the Surma Valley but also in the province of Assam, India had an area under tea of 75,500 acres in 1952 producing 41.3 million lb. tea with an average yield of 551 lb. per acre.

The Surma Valley comprises four tea areas, Cachar, mentioned above, Sylhet and Chittagong, which are in Eastern Pakistan, and Tripura or Hill Tippera, a native state administered by India and lying between Sylhet and Chittagong. The tea area in Eastern Pakistan totals 73,376 acres of which about 67,500 are in Sylhet and the rest, 5,800 in Chittagong. The total production of tea in these areas in 1952 was 53.1 million lb. average 725 lb. per acre. The area under tea in Hill Tippera is 9,000 acres.

In the Surma Valley, the tea districts consist mostly of long narrow valleys running to the Surma. The valleys are formed by ranges of low hills, usually bamboo clad, which are thrown off from the main range. Innumerable hillocks or *teelas* are dotted over the the valleys and these, together with the flats between the valleys, carry the tea. In some instances the flats have collected water which has been unable to get away and, as a result, a bog or *bheel* has been formed which on draining grows vigorous tea.

The tea districts of the Dooars and Terai form a long, narrow strip of land adjacent to the Himalayas. This area is cut transversely by large rivers, some of which are of the swiftest in India. The scenery of both districts is dominated by the Himalayan range, presenting a mountain mass capped by snow which can be described as majestic.

In the Himalayas there are limestone outcrops and the soil in the vicinity of such is likely to be alkaline and unsuitable for tea. Parts of the Dooars are liable to trouble in this respect, and further along the Himalayas, in the Bisnauth sub-district of Darrang, Assam similar alkaline patches occur. No such conditions have so far been met in the tea areas on the south bank of the river, although limestone outcrops occur in parts of the Mikir Hills.

The Darjeeling tea area is a hill district and unique in this respect in North-East India. The tea is put out at various altitudes up to 6,500 ft., although the average is between 3,000 and 4,000 ft. The tea district is a small rectangular area twenty miles square surrounding the town of Darjeeling, the summer capital of Bengal. The town is situated at a height somewhat under 7,000 ft., and commands an inspiring view of the snowy range of Bhutan, Tibet and Nepal, dominated by the Kinchinjunga group.

Darjeeling, the Terai and the Dooars are all in the province of West Bengal. The area under tea in Darjeeling is 42,000 acres, in the Terai 20,000 acres and in the Dooars 134,000 acres. The total area in 1952 was 196,648 acres producing 157 million lb. tea. About 2,000 acres of the tea in the Bengal Terai are actually planted in the Bihar province. In Nepal, across the boundary from Darjeeling, an area of 300 acres is planted to tea.

The Climate of North-East India

The year in northern India may be divided into three seasons, the cool and the dry lasting from November to February, the hot and the dry from March to June, and the hot and the humid from June to October. After the monsoon current is established in the Indian Ocean, it splits into two main components to the west of Ceylon, one running up the east coast of Africa eventually to make a turn eastwards at the Abyssinian Plateau, thence to the Bombay coast, and the other, the Bengal current, moving round the Bay, serving southern Burma then Bengal and northern India.

It will be seen that North-East India is out of the main track of the monsoon as it is understood in its narrower sense in India. Yet on account of the general drift of moist air towards Central Asia, clouds pass over Bengal during the dry, hot season and throughout the monsoon period and enter the funnel formed by the Brahmaputra and Surma Valleys. Here they are shepherded round the hills till they are deposited as rain. On this account North-East India receives rain when the rest of northern India is in the grip of the fierce spring drought, and Assam is one of the permanently green corners in a continent where conditions are often arid.

The topography of North-East India is such that the precipitation varies widely from place to place. The average rainfall is about 100 in., but in some places in the Mikir Hills the figure is as low as 40 in. On the other hand Cherrapunji, situated about 4,000 ft. up, on the edge of the Shillong Plateau facing south and overlooking the Surma Valley, is one of the wettest spots on earth, with an average annual rainfall of 381 in. and a maximum record of 905 in.

There are two distinct air drifts into North-East India, the

main one into the Brahmaputra Valley, and the other into the Surma Valley which crosses the Barail Range into the Brahmaputra Valley where it augments the main drift. In the Dooars, which take the first onslaught of the air movement, where its northern component is deflected to the east by the wall of the Himalayas, the annual rainfall is 140 to 200 in. Then there is a decrease through the valley as far as Tezpur, where it is only 70 in. The Surma Valley current is then joined and precipitation increases up the valley to over 100 in. at Dibrugarh.

In the Surma Valley, conditions and the lie of the land are different from those in the Brahmaputra Valley. Thus at Chandpur, at the mouth of the valley, the rainfall is 90 in. after which it steadily increases to the rain divide at Nimotha in the Barail Range where it is 200 in. Further on, at Lumding, in the leeway of the divide, precipitation is only 50 in. and this area is considered too dry for tea planting. In Golaghat, further up the Assam Valley, with rain coming from both currents, the total rainfall is over 70 in. and a first-class stand of tea is possible.

The table below shows the average monthly rainfall in Upper Assam, in the Surma Valley, in the Dooars and in Darjeeling. The average maximum and minimum temperatures in the Surma Valley and the Dooars are similar to those shown for Tocklai, Assam in Chapter II, except that in the spring they are a few degrees higher, and accordingly the early months of the season are more difficult. Temperatures in Darjeeling differ widely according to altitude and may average 10° F. lower than those in the plains at altitudes about 3,000 ft., and by as much as 20° lower at the altitude of 6,000 ft.

The minimum annual rainfall desirable for tea under conditions in North-East India has been put at 60 in., although 80 in. are preferable.

TABLE SHOWING MONTHLY RAINFALL IN NORTH-EAST INDIA

		<i>Doom Dooma</i>	<i>Silchar</i>	<i>Mal</i>	
		<i>Assam</i>	<i>Cachar</i>	<i>Dooars</i>	<i>Darjeeling</i>
		<i>in.</i>	<i>in.</i>	<i>in.</i>	<i>in.</i>
January	. .	1.5	0.6	0.5	0.8
February	. .	2.8	2.3	0.7	1.1
March	. .	5.9	8.0	1.1	2.0

	<i>Doom Dooma</i> <i>Assam</i> <i>in.</i>	<i>Silchar</i> <i>Cachar</i> <i>in.</i>	<i>Mal</i> <i>Dooars</i> <i>in.</i>	<i>Darjeeling</i> <i>in.</i>
April . . .	10·7	13·6	4·0	4·1
May . . .	10·6	15·7	11·1	7·8
June . . .	15·8	20·4	33·4	24·2
July . . .	19·6	20·0	44·5	31·7
August . . .	16·3	18·7	28·2	26·0
September . . .	10·6	14·0	28·7	18·3
October . . .	4·5	6·4	7·5	5·4
November . . .	0·6	1·3	1·0	0·2
December . . .	0·4	0·5	0·2	0·2
Total	99·3 in.	121·5 in.	160·9 in.	121·8 in.

Frosts are never reported in the tea districts of Assam, although they have been known on rare occasions in parts of the Dooars, well south of the hills.

Except during parts of March, April and May, the atmosphere is saturated each night in North-East India. The relative humidity is usually about 90 per cent at 8 a.m. and as the day advances it falls to 60 per cent or less in dry weather. The absolute humidity shows a value of about 0·5 in. of mercury in January. In March or April it begins to rise and reaches a figure of 0·7 in., at which it remains till the end of the monsoon, when it falls sharply to 0·5 in. in December. There is an appreciable direct correlation between the variation in the absolute humidity during the season and the tea crop.

In the cold weather the wind direction is generally from the north-east, whence it blows cool and dry. In December a depression often moves across India from Iran and brings what is spoken of as 'Christmas rain'. In the monsoon the air movement is from the south or south-west. The early months of the year are the most windy, and during March, April and May hurricanes often blow, sometimes accompanied by hail. The latter contingency is a real danger, for a hail-storm may well strip a whole area of leaf and young shoots. The hailstones are sometimes up to 1 in. in diameter and do great harm to the wood of the bush. Estates liable to hail insure against such damage. Cut-back tea should be sprayed with lime-sulphur

after hail damage, whilst all tea so affected should be dosed with extra fertilizer.

The amount of sunshine is an important climatic factor for it not only controls the air temperature but also affects the incidence of some pests and blights. The daily sunshine in the Assam Valley averages six hours, and the least sunny month is September with four hours average a day. In the Dooars, during the monsoon, there is somewhat less sunshine than in other tea districts, but the difference is not as great as is often suggested. The solar radiation or sun temperature, as measured by a black bulb thermometer, varies between an average maximum of about 115° F. in January to 155° in July. These values are independent of the air temperature, and are about the same for Darjeeling as for the plains.

The Tea Soils of North-East India

Most of the tea soils of North-East India are alluvial in origin, the main exception being those of Darjeeling which were formed *in situ*. The nature of the climate makes for a movement of water through the soil and at the high temperatures during the wet season such movement brings about laterization. This last involves the leaching-out of lime and bases like potash and magnesium and, as a result, the formation of an acid soil. The lime content of good tea soils in North-East India lies between 0.2 and 0.1 per cent, half of which may be in a form available to the plant. Tea thrives on an acid soil and it is considered the optimum pH in North-East India is 5.4, and that with values above 6, the soil probably needs treatment if tea is to do well.

Provided the soil is sufficiently acid, the vigour of the tea stand depends largely on the abundance of available nitrogen in the soil. In assessing the nitrogen status, it is considered indicative to base it on the reactive part of the soil. Thus, if the insoluble silicious matter in a soil is 90 per cent, as it is in Jorhat and Bishnauth soils, then the total nitrogen should be calculated as a proportion of the soluble 10 per cent of the soil. In this way it is concluded that 0.8 per cent nitrogen calculated on the non-silicious fraction is the minimum necessary for the establishment of economic tea.

No definite figures can be given regarding the potash and

phosphoric acid requirements in the tea soils of North-East India. Aluminium and manganese may be necessary, and this probably links up with the need tea shows for an acid soil. The effect of minor elements on tea growth in Assam has not been studied yet and so far there has been no obvious problem in this direction.

It is considered that a soil 5 ft. deep is desirable, and a loam is preferable to clay although the latter often gives tea of quality. The top 3 ft. of soil should never remain in a saturated condition.

The floor of the Brahmaputra Valley is of the same rock that forms the core of the Shillong Plateau, but this is overlaid with alluvium which in the middle of the valley is thousands of feet in depth. Near the Big river itself, recent deposits are almost neutral in reaction but further back the older deposits have had time to weather and develop acidity. The alluvium laid down by the Brahmaputra is usually of much more recent deposit than that eroded from the foot-hills which surround the valley. Thus there are alluviums of various textures, ages, degrees of laterization and of fertility.

In the Surma Valley the alluvium is derived from the surrounding Tertiary sandstone. A characteristic of the valley is the *teela* or low hillock composed of weathered sand and often showing nodular pans. Between the *teelas* are flats, which vary in texture from sand to heavy clays. A small proportion of tea is planted on *bheel* soils, which are areas once occupied by lakes that on draining expose peat soils. Both *bheel* and *teela* areas present problems in management. The former soils deteriorate after twenty years or so of cultivation whilst the latter suffer from erosion. *Teelas* facing south and south-west are sun-baked and usually carry poor tea.

In the Dooars and the Terai the tea estate soils have been brought down from the adjacent Himalayas. They vary in age and colour from Red Bank, which are the oldest and reddest, then the Plateau soils which are younger, less red and less weathered, then the Mal sands which are brownish in colour, and finally the Grey Sandy Loams of the Central Dooars which have had little time to weather and, as a result, are often rich in lime and magnesia. The younger soils are still closely related chemically to the parent rock which gave rise to them. In this

connexion it is to be noted that in the hills to the north of the Central and Eastern Dooars are dolomite rocks and limestone tufa. The mineral dolomite is a carbonate of lime and magnesia. The alkaline deposits from these rocks are harmful to tea and pose a serious problem to planters in the areas which are affected by such deposits or by flood waters made alkaline by contact with such rocks.

In the Darjeeling district the typical soil is a chocolate-coloured loam formed *in situ*, although some of the soils resemble those seen in the Dooars.

The Peoples of North-East India

North-East India is situated between Burma, Tibet, Bhutan and Nepal, and is the home of many tribes. The ethnology of the area has received considerable study and is set out in an extensive series of monographs.

The mountains are peopled by primitive tribes who come to the plains in the cold season for the purpose of barter, although a few years ago their visits took the form of raids. The Himalayas from the Dooars to Mangaldi are inhabited by Bhutias, and further east successively by Akhas, Daphlas, Arbors and Mishmis. The Miris occupy certain river areas in the Assam Valley. On the south of the valley the hills are peopled by various Naga tribes. The hills of the Shillong Plateau are occupied by Mikirs, Khasias and Garos. The aborigines of the valley, the Kacharis, live mainly in these hills. All these people are animists.

The present inhabitants of the plains of Assam are the Assamese, largely descendants of the Burman invaders who began to filter into the country in the thirteenth century and to dispossess the Kacharis then in occupation of the plains. The Assamese are Hindus mostly, and are of Mongolian stock, as are also the hill tribes.

Compared with other parts of India, Assam has little history, and what there is is largely centres round Sibsagar. The only buildings and works of merit now remaining are to be seen round this town in the form of temples and extensive earth tanks, but none of these are of great age.

There has been a steady flow of labour into Assam from other parts of India, for the Assamese do not regularly work in tea

estates and the hill peoples only do occasional work like jungle felling. Labour is recruited largely in Bihar, Orissa, the Central Provinces and Madras. Many labourers after a spell of work return to their country, but the rest either remain on the estate or acquire land in Assam.

In the Surma Valley the plains population is mainly composed of Mohammedans who originally came from Eastern Bengal and are now known as Sylhetis. Of the hill people, the Manipuris and Lushais are the commonest.

The Dooars and Terai constitute what was once part of Bhutan and Nepal, although the natives of these areas are Mechis. The garden work is done largely by Nepalis, but a great deal of labour is also imported from the plains of India. In Darjeeling most of the work is done by Nepalis and natives of the district. The Bhutias do not work on tea estates.

Before the recent war, the north-east frontier of India was a peaceful one, in contrast to that of the north-west. Then hostilities came right into the province with severe fighting at Kohima in Manipur, whilst a few of the enemy actually reached Naojan, on the railway between Sibsagar and Manipur Road. Lakhimpur supplied air fields for the take-off to China and the whole of Assam became an armed camp. Planters took thousands of workers to make air strips and to build roads into Burma. The war effort in North-East India was of an epic nature.

Communications in North-East India

Until the beginning of this century the main traffic artery of Assam was the Brahmaputra. In 1847 the Government formed an irregular service of paddle steamers between Calcutta and Gauhati which was made a daily service in 1883. In 1887 a similar service was placed on the Surma River. Today regular steamers run between Calcutta and Dibrugarh, a distance of about 1,000 miles which is covered in a fortnight.

The first railways in Assam were the Jorhat Provincial and the Dibru-Sadiya, opened about 1885 and designed to take stores and tea between the estates and the river steamer ghats. In 1905 the Assam-Bengal metre gauge line was constructed from Chittagong, through the Surma Valley, across the Barail Range at Haflong to the Assam Valley at Lumding, thence to

Tinsukia where it joined the Dibru-Sadiya line. This outlet was not entirely satisfactory because it lay partly along a geological fault between the Naga and the Jaintia Hills, with the result that landslides were common.

Later on the line from Lumding to Gauhati was opened offering an alternate route to Calcutta, although the river steamer from Gauhati to Dhubri had to be taken, and here the railway was joined again. The last link in the line from Assam to Calcutta was between Lalmonirhat and Gauhati and this was opened in 1910. The importance of the hill section over the Barail Range thereafter declined. It is still necessary to tranship across the Brahmaputra at Gauhati for the river is unbridged throughout its course.

Branch railway lines connect most of the tea districts either with the main line or a steamer ghat. When the State of Eastern Pakistan was formed in 1947 this new country cut across the Assam line between Gauhati and Bengal, and to keep the track wholly in Indian territory the Link Line running through the Terai and the Dooars, close to the hills and north of Eastern Pakistan was laid.

There is a lack of road metal in Assam and until recently the roads were bad. Since the war however, many good main roads have been built in both the Assam and Surma Valleys. In the Dooars road metal is plentiful and the road standard there always has been high.

Since the war, much long distance travel in North-East India is done by air. There are regular air services and many privately owned planes. It is mentioned here that although no visiting agent would rely on an air survey to assess the condition of an estate, such a survey at a low altitude gives a very good general idea of the stand both of the tea and the shade, and supplies information not obtainable from a surface inspection.

The Beginning of Tea in India

The early history of tea in India is bound up with the history of the British connexion with the province of Assam. Many Europeans who had had experience in Upper Assam during the early part of the nineteenth century knew that tea was growing in the country of the hill tribes (Singphos) at the north-eastern end of the valley, and was used for making

tea after the Burmese method, by which the leaf is pickled.

In 1823 R. Bruce, an adventurer and trader, visited Garhgaon, near Sibsagar for trading purposes and having heard of the existence of tea plants from a Singpho chief, made arrangements to obtain some specimens. In the following year these arrived and were made over to his brother C. A. Bruce, who was on service in charge of a flotilla of gunboats at Sadiya, on the Brahmaputra, in the Burmese War then in progress. The Burmans had been making raids into Assam and the Assamese had appealed to the British for assistance. In 1825, at the end of the war, C. A. Bruce settled in Sadiya and put out most of the tea plants in his garden. A few specimens were sent to Captain David Scott, the first Commissioner of the newly acquired province of Assam, and he forwarded them to Calcutta for identification, together with supposed tea leaves he himself had discovered in Manipur. Identification was of course impossible without seed or flower, but the leaves were pronounced to be of the same family but not the same species as the plant from which the Chinese manufacture tea.

In 1833 the East India Company, having lost its monopoly of the tea trade with China, was anxious to obtain a rival source of supply under its own control. As early as 1780 a few shrubs had been imported from Canton and planted in Calcutta. In 1788 Sir Joseph Banks, the naturalist, at the request of the Company studied the problem and suggested Bihar and Cooch Behar as suitable areas for tea culture. The question of tea production in India was not therefore a new one when Lord Bentinck, the Governor-General, appointed a committee in 1834 to go into the matter. At the same time the secretary of the committee, Mr. G. J. Gordon of the Calcutta firm of Mackintosh & Co. was sent to China to bring back plants and seed and also cultivators who knew how to grow and prepare tea.

The conclusions reached by the Committee based on analogies, often false ones, of climate and soil, convinced them that the proper places for tea cultivation were, in order of suitability (a) the lower hills and valleys of the Himalayas, indicating Mussoorie, Dehra Dun, &c. (b) the eastern frontier and (c) the Nilgiris and the mountains of central and south India. Exactly which area was denoted by the eastern frontier was not stated.

Captain Jenkins, then in charge of the Assam Valley, stationed at Gauhati, heard of the Committee and communicated with Lieutenant Charlton, on service at Sadiya. As a result of this, complete tea plants, including seed and flowers, were despatched to Calcutta (on 8th November, 1834) and were identified with certainty as the same species as the China tea plant.

This re-discovery of tea in Assam caused a stir in interested circles in Calcutta. Dr. N. Wallich, then Superintendent of the Botanical Gardens, considered that in view of the presence of tea in India the importation of the China stock was a waste of time. Partly on this account Gordon was recalled from China, although not before he had despatched several lots of seed to India.

In the meantime local progress had been considerable. Tea was discovered in the Manipur Hills, in Tippera and in new localities in the Assam Valley. The experiments with the China seed were taken over by C. A. Bruce who became the central figure in the local development of tea culture for a good many years.

In 1835 a scientific deputation was sent to Assam to report on the possibilities of developing the industry there. The party reached Sadiya in 1836 and found the tea nurseries, grown from the seed sent from China, in a bad way, overgrown with weeds, suffering from cattle trespass and the poor soil. Of the 20,000 plants sent from Calcutta only 500 were alive.

The deputation found tea in many parts of the valley, including Kutchu, Negrigram, Nadua, Tingri, Gabru-Purbat and Borhat, besides in the hills between Assam and Burma. No plants were found north of the Brahmaputra River and those found on the plains were always in groups, almost as if they had been planted. The Matak country, between the Dibru and Dihing rivers, was full of such groups. As the country had been desolated by war for many years it is quite probable that the tea bushes found on the plains had been planted. Only in the Singpho Hills did they become apparently part of the ordinary vegetation. Thus the question whether tea is indigenous to Assam was left in doubt, and so it has remained.

In 1836 C. A. Bruce was made Superintendent of the Government Tea Forests and during the next few years did very fine

pioneer work. In 1838 he published a pamphlet which included a map showing the extent of his discoveries of wild tea. In the Matak country he located eighty tea tracts, in the Singpho twelve, and west of the Buri Dihing twenty-eight. The last were notably at Namsang, Tipam, Jaipur and in the neighbourhood of Rangpur (Sibsagar) and Gabru.

When the first seeds which were sent by Gordon arrived from China, they were sown in Calcutta early in 1835, and the young plants 42,000 in number, were distributed between Assam, the Himalayas and the Nilgiris. The plants did well in the Himalayas, practically all those sent to the Nilgiris died, whilst those sent to Assam were planted on a sandy *chur* at Kundilmukh near Sadiya where, as previously mentioned most of them failed.

Besides these ill-fated plants, a beginning was made with the exploitation of wild Assam tea and in one case in order to work up or reclaim the Assam plant as rapidly as possible, wild and China tea were interplanted. The experiment ended, happily, in the death of both varieties. Subsequent experience showed that neither the China plant nor a China-hybrid does as well in North-East India as the indigenous plant. Meanwhile many jungle patches of tea were cleared with varying success.

In 1838 a new plantation of China tea was put out at Jaipur, and later one at Deenjoy, Chabua. A few of the original plants are said still to exist at Jaipur, planted 6 by 6 ft. At Chabua, the supposed original tea, now abandoned, can be seen planted in irregular lines. In 1838 or 1839 three more gardens were put out, one near Deohall, the second at Chota Tingri and the third at Hukanpukri.

The idea of those interested in tea in Assam was still to plant China bushes, but as these took time to mature, tea was prepared from leaf plucked from indigenous bushes. The first tea good enough to send to Calcutta was made in 1836, although during this year and the next only small samples were produced. In 1838 enough was made for despatch to England where it was awaited with great interest. At its sale on 10th January, 1839 it sold for an average of more than 20s. per lb. a price indicative not of its true value but rather of its novelty. All this tea was manufactured after the Chinese manner by imported Chinamen.

It had now been shown that tea could be made in Assam and a number of capitalists approached the Government, both in London and Calcutta, for the transfer of the Government plantations to themselves. A company termed the Bengal Tea Company was formed in Calcutta in 1839 and in the same year a joint stock company was also formed in London with a similar object, viz. the purchase of the East India Company's plantations and establishment in Assam for the purpose of carrying on tea cultivation there. The two companies almost immediately amalgamated as the Assam Company. In 1840 two-thirds of the experimental tea were handed over to the new company and C. A. Bruce was made Superintendent of the northern division with headquarters at Jaipur.

Chabua was sold by Government to a Chinaman in 1840, but in 1851 it was taken over by Messrs. Warren and Jenkins who in the next year entered on the formation of the Maejean Tea Barree.

To return now to the Assam Company, the earliest trouble was lack of labour which was not obtainable locally in sufficient quantity. Large numbers of Chinese were imported first, the supposition being that every Chinaman was capable of cultivating, manipulating and preparing tea. The experiment was a failure and the Chinese were described as 'turbulent, obstinate and rapacious'. Labour recruited from India also proved unsatisfactory, largely on account of the unhealthy nature at the time of the country round Nazira.

In spite of these troubles the Company had 2,638 acres under tea in production in 1841 although the number of plants per acre was only 457. Most of the area consisted of groups of plants found in the jungle and cut down for cropping. The total amount of tea produced in this year amounted to 10,712 lb. but the cost of production was enormous. In 1852 this Company, the first tea company in India, paid its initial dividend. The second limited liability company to be formed with its estates in Assam was the Jorehaut Company in 1859.

The original holdings of the Assam Company were extensive and included large areas in the Tingri and Jaipur districts as well as land in Darrang (Singri Purbut) and Cachar. The Tingri and Jaipur areas were sold to the Northern Assam Company in 1863 and the Cachar division to Mr. Grob in 1864.

In 1859 Colonel Jenkins, then the Agent Governor-General of Assam, published a list of tea gardens established in Assam. This list included thirty-odd names most of which are familiar today.

Meanwhile in 1855 indigenous tea was found in the Chandkhani Hills in Sylhet, and tea was put out in the Surma Valley as the combined districts of Cachar and Sylhet are termed. Later on tea was found wild along the Khasia and Jaintia Hills where they border the Surma Valley, and for some time the presence of indigenous tea was taken as a sign that the area was suitable for tea growth. The first tea in Cachar was put out in Barsanjan in 1856 on the hilltops which stretch from the Barail Range to the Barak River. The *teelas* (hillocks) were next planted out and in 1875 the first *bheels* (swamps) were drained and planted. In Sylhet the first garden put out was Malnicherra in 1847.

About the same time tea planting began in Darjeeling. By the end of 1856 tea had been cultivated at Tukvar, at the Canning and Hopetown plantations, on the Kurseong flats and between Kurseong and Pankhabari. After the industry had been established as a commercial enterprise in the Darjeeling district, attention was turned to the Terai where Champta was put out in 1862. The land east of the Teesta river was soon after explored and Gajaldhoba was planted in 1874, followed later by Phulbari (Leesh River) and Bagrakote. The tea area spread eastwards till it ultimately reached the Sankos, the boundary of Assam. The area between the Teesta and the Sankos, spoken of as the Dooars, now constitutes one of the most compact tea areas in North-East India.

Organization of the Tea Industry in North-East India

During the later decades of the nineteenth century many tea estates were opened in North-East India by individuals or as family concerns. Subsequent development has been mainly by limited liability companies. In the early days, the length of the journey from England to India made it practically necessary to have a Calcutta agent to look after the business interests of the estate in India. In spite of present rapid transport, the need for the Agency House persists, for such a system gives the benefit of a steady policy in estate management, and makes for

co-operation amongst the sellers in shipping and marketing their crops. Most Agency Houses have considerable holdings in the concerns they manage.

The Indian Tea Association, Calcutta was formed at a meeting of Calcutta agency firms in 1881, the object and duty of the Association being to promote the common interests of all persons concerned in the cultivation of tea in India. The original membership represented a planted area of 103,000 acres, and this by 1925 had increased to well over $\frac{1}{2}$ million acres at about which figure it has remained.

The Indian-owned tea concerns have an association known as the Indian Tea Planters Association with headquarters at Jalpaiguri, in which district (the Dooars) are many Indian-owned estates. This Association works on the same lines as and in co-operation with the older body.

Among the many activities of these Associations those connected with the recruitment of labour, the development of foreign and home markets, the regulation of tea exports in order to balance the supply of the commodity with demand, and with scientific research may be mentioned.

The tea industry has an association for managing its labour affairs and as early as 1859 a Tea Planters' Association was formed to regulate the recruitment of labour from Lower Bengal. The sudden expansion of the industry about this period led to disastrous competition in the recruiting areas and in 1861 the Government appointed a committee to enquire into the system of recruitment by contractors. As a result, various emigration Acts were passed till finally in 1915 recruitment by contractors was abolished and the Assam Labour Board created. In 1917 the various planting associations connected with the supply of labour were amalgamated under and name of the Tea Districts Labour Association.

From the year 1893 the Indian Tea Association collected a voluntary assessment for expenditure on the development of foreign markets for Indian tea. There were however objections to raising money by this system and in 1903, at the request of the Association, the Indian Tea Cess Act was passed. By this means a cess of $\frac{1}{4}$ pie per pound tea (just over 2d. per 100 lb.) was levied on each pound exported. In 1923 the rate was raised to 4 annas ($4\frac{1}{2}d.$) per 100 lb. and the Act was amended

to enable the levy to be raised to 8 annas if necessary. In 1933, the maximum rate was applied. At present (1955) the rate is Rs.4 (6s.) per 100 lb. tea exported and the sum collected amounts to £1½ million on 500 million lb. tea. The cess is collected by the Customs Department and the proceeds made over to the Cess Committee.

At the time the cess was instituted, the Committee decided to concentrate on pushing tea sales in America and this work has continued since. Efforts to popularize tea on the continent of Europe and in Africa have also been made and much has been spent in India itself. Before the start of the propaganda in India in 1915, the sale of tea averaged about 18 million lb. annually. By 1930 it had risen to well over 50 million lb. and now it is between 150 and 200 million lb. per annum.

In 1933 the serious slump in tea prices brought the three main tea exporting countries, India, Ceylon and the Netherlands East Indies, into close co-operation regarding the export of tea, and an International Tea Regulation Scheme was agreed upon. In conjunction with this Scheme the International Tea Market Expansion Board took over the work of expanding tea consumption outside the producing countries, using the cess raised in all three countries. Later the African territories joined the Board and tea, irrespective of its country of origin, was publicized in Great Britain, America, Europe and Africa. Recently, rearrangements in the composition of the Board have taken place but the advertising of tea abroad continues to be a joint undertaking.

The Indian Tea Association started a Scientific Department in 1900, with laboratory accommodation in Calcutta. Later a laboratory at Heeleaka near Mariani, Assam, was equipped. In 1911 the Station was moved to its present site at Tocklai near Jorhat and from that date it has grown steadily. The expenses of the Department are met by subscription on an acreage basis collected from all companies in the membership of the Association.

Statistics

The table below shows the acreage under tea in North-East India and the production in 1952 compared with parallel figures for South India, Ceylon, Indonesia and the combined

total for Eastern Africa, comprising Kenya, Uganda, Tanganyika, Nyasaland, the Belgian Congo, Mozambique and Southern Rhodesia.

TEA ACREAGE AND PRODUCTION IN 1952

<i>Tea area</i>	<i>Acres</i>	<i>Production lb. tea</i>
North-East India . . .	671,456	552,401,000
South India	172,495	110,845,000
Ceylon	572,008	316,842,000
Indonesia	193,528	82,181,000
Eastern Africa	94,811	46,320,000

The figures illustrate the commanding position held by India in the way of production. The Ceylon area includes 68,981 acres of small holdings. The present area of Indonesia compares with a pre-war figure of 530,489 acres which included 184,981 acres of small holdings. The 1952 figure comprises only those estates at present in exploitation in Indonesia and includes no small holdings.

The expansion of the area under tea in North-East India and the changes in yield per acre from 1885 to the present provide figures for study and speculation.

ACREAGE, CROP AND YIELD IN NORTH-EAST INDIA

<i>Year</i>	<i>Acres</i>	<i>Crop million lb.</i>	<i>Yield lb. per acre</i>
1885-9 . . .	284,470	86	306
1900-4 . . .	476,403	190	400
1914	535,679	284	530
1924	594,692	324	540
1932	657,555	368	560
1944	656,464	405	620
1952	671,456	552	820

The first point of interest to be noted is the big expansion in acreage round the end of the nineteenth century, when twenty years witnessed an increase of about 200,000 acres. During each decade from 1904 to 1932, a further 60,000 acres approximately were planted. The year 1932 marked the climax of the slump in prices which started in 1928, and the International Tea Regulation Scheme inaugurated in April 1933 shut down on extensions of tea areas. Thus from that year the acreage changed little over the following twenty years, remaining at about 660,000.

The yield per acre from the period 1885-9 up to 1914 increased at the rate of about 9 lb. tea per acre per annum. During the 1914-18 War, yields rose to 640 lb. per acre due to coarser plucking, but after the war the crop fell back to about 560 lb. round which figure it remained throughout the restriction period, up to the outbreak of World War II. Over the restriction years, from 1933 to 1939, the permitted crop from North-East India ranged from 318 million lb. in 1933 to 372 million lb. in 1938.

During the restriction years 1933-9 much poor tea was uprooted and replanted and the rest of the area usually lightly plucked. Hence when the Second War came the stand was in good fettle and in 1942, after Indonesia had been overrun and ceased to export tea, North-East India harvested 470 million lb. an increase of 100 million lb. above the previous best.

After this the crop tailed off, partly because of lack of fertilizers, which were unobtainable during the war years, and in part because many tea planters and hosts of the labour force went to build roads and airfields for the Army in Assam. In 1946, with the return of labour, the crop increased again, up to 492 million lb. and each season it rose steadily, reaching its banner year in 1950 with 565 million lb. making an average of 842 lb. tea per acre.

This marked increase is due in part to coarser plucking. Other factors making for the increase have been the steady improvement in the type of tea planted over the past twenty years, improved field methods and the more scientific use of shade trees and fertilizers.

Other trends since 1940 are of great importance and merit study. Thus since 1939 labour costs have increased fivefold whilst housing, medical facilities and general amenities have all gone ahead. Yet in spite of this the cost of production of the tea has only increased about threefold, a state of affairs due in part to higher yields and partly to improved output per worker.

The number of workers before the war and indeed generally from 1900 to 1944 was about 1.2 per acre, reckoning a junior as half an adult. Since the war the labour per acre has increased to about 1.5, which is less than what might have been expected from the increase in crop. In 1900 one worker per 400 lb. tea produced was employed, and this figure improved till in 1914

one worker per 480 lb. tea was the average, a figure maintained till 1939. Then a sharp rise in output took place, and now one worker per 640 lb. is about the average although many of the highest yielding estates reckon to employ only one per 800 lb.

Several factors are involved in this improved outturn per worker, one of the chief is the improved health of the labour force. In 1944 mepacrine was issued as a febrifuge to all the labour, in place of quinine. As a result, on one estate the average number of fever cases treated monthly during the monsoon fell from 150 to eight. Similar experience was common in fever areas. In 1945 paludrine was used in place of mepacrine and fever was practically banished. Now the houses of the labour are periodically treated with D.D.T. and a further improvement in general health has been registered. At one time the labour needed persuasion to work: now it wants to work. Other factors involved in the increased outturn per worker are the greater incentives of improved pay and conditions.

No doubt yields will continue to rise. Already many estates average 1,200 lb. tea and a few turn out over 1,600 lb. per acre. Large yields make for somewhat lower production costs. However much leaf is harvested, the cost of plucking, manufacturing, packing, transit and sale charges remain the same for each pound of tea made. Saving is made in field work and overhead charges. The profits per acre increase as the yield, provided the quality of the tea is maintained.

CHAPTER X

FIELD METHODS IN NORTH-EAST INDIA

*Clearing the land—Tea seed gardens and tea seed—
Nurseries and planting out—Pruning—Plucking—Cultiva-
tion—Manuring—Pests and diseases.*

IN this chapter, present-day methods and procedure in the field are described, and the way in which such were arrived at is also outlined. When the industry started in 1839, the China plant had been imported and grown and China methods both of culture and preparation were used. The China plant soon lost favour but it took a century to work out rational field methods. Even as recently as 1925 most estates in Assam were regularly deep cultivated, the bushes were collar-pruned or periodically heavy-pruned, whilst flat, table plucking was by no means standard. The full value of leguminous shade trees was not appreciated, and artificial fertilizers were regarded with suspicion. Today practically every field operation is still the subject of trial and experiment, but all estates attempt to follow what is now generally accepted as standard procedure.

Clearing the Land

There has been no extensive opening of tea lands in North-East India since 1933, when the International Tea Agreement provided not only for the regulation of exports but also for the control of extensions to the tea area.

Before 1933 new estates were often put out as extensions of existing ones, and when a sufficient acreage was reached the new area was supplied with a separate factory and staff. Such a way of development was considerably cheaper than starting fresh somewhere in the jungle.

When entirely new estates were opened up, first of all a suitable site for labourers' houses was chosen, a simple house was built for the manager, then the clearing of the jungle began

and nurseries were planted out with purchased seed. The work started at the end of the rains. People of the hill tribes often took on jungle felling, but apart from this there was usually a migration of labour to a new estate from surrounding areas, and this formed the nucleus of a new force. Labour was also recruited.

In the early days, jungle clearing began with the cutting of brush wood and burning it when dry. The trees were then felled, leaving a short stump, the branches lopped and fire again sent through. The heavy timber was sometimes left to rot where it fell, or it might be rolled into depressions and left, or collected for engine wood and charcoal. As an alternative, timber might be collected and burnt in a pile although the alkaline ash so formed could account for a weak patch of tea later. The tree stumps were often left to rot in the ground, a process which takes only five to six years to complete, so rapid are the agents of decay in their work. But the aftermath of such is often patches of tea killed by root disease in the area where the stump was left.

When grass land was cleared, the grass was cut, the roots of elephant grass grubbed up and the whole burnt. The area was then planted with seed at stake. If the spring rains were good such methods often succeeded, although failures were frequent.

In later years, clearing was done with more care, tree stumps removed, the land completely hoed and seedlings with a clod of earth planted. As long as thirty years ago tractors were used for clearing and cultivating before planting. No doubt when extensive planting begins again in North-East India, further mechanization will be introduced.

Tea Seed Gardens and Tea Seed

Tea seed is usually grown in small areas, ranging from 10 to 50 acres, attached to a tea estate but isolated from the tea in plucking or even planted in a jungle clearing some distance away. The name of the estate is usually given to the seed and this is the *jat* or commercial name. The *jat* has no connection with the race or variety of the seed, but it nevertheless may have great significance and value when the seed has built up a reputation.

The plants for a seed garden are chosen according to the

planter's fancy which is based on his experience. It is generally considered that the Assam or Shan type gives good quality tea and does well in Assam, whilst the Burma type is more hardy but does not give as good quality as the Assam. The Lushai type is undesirable. The China and China-hybrid types are wholly unwanted in the plains of North-East India, although they are grown in Darjeeling on account of the flavoury teas they produce there.

In the pioneer days the seed was taken from the so-called wild tea found growing in Assam, only that from good-looking bushes being employed. A nursery was then put out and further selection made. By 1900 the four main types of tea plant had been separated to some extent although much still remains to be done in this connexion even now.

In recent years new seed gardens have been put out from the finest seed obtainable of the type to be grown and this is again selected in the nursery. After the seed garden is planted, undesirable trees are de-rogued, and one or two 'mother' trees having vigour, desirable branching habit and the right kind of leaf are selected to give further seed. Such trees are of course cross-pollinated by surrounding trees, but one parent is known and some advance in selection is thereby made. Thus a *jat* of seed may steadily change for the better provided the right characteristics are selected, and as a result many *jats* are very even as far as leaf appearance is concerned.

In a recent scientific survey of the tea seed gardens of North-East India it was shown that 7 per cent of the *jats* were of the Lushai type, 70 per cent Shan type, 21 per cent Burma and 2 per cent of the China type.

In the survey just mentioned, the *jats* were judged for quality by the degree of pubescence (hairiness) of the leaves. In this way, only 4 per cent of all the gardens were considered capable of producing teas markedly above average quality.

It is curious that, in the past, seed bearers have not been chosen partly on account of pubescence of the leaves for it is well known that 'tip' in tea is due to hairy buds and leaves, and that tippy teas are quality teas. The word *pek-ho* in Chinese denotes the white hair or down on the younger leaves, and up till the beginning of the century the finest grades of Indian tea were the Pekoes.

There are now carefully worked out schemes in hand in Assam to produce clonal seed, either by line breeding, from two selected and tested plants, or by mass selection from a number, usually nine, of desirable plants. There are potential dangers to be faced when the range of plant entities in a seed garden is thus reduced, especially in line breeding, for the vigour of the hybrid swarm may be lowered thereby. Nevertheless, when the schemes are worked out the industry is likely to have seed giving better plants than ever before. There is no doubt that the present method of selecting plants for seed bearers will give way to the use of generative clones, grown as cuttings from tested bushes and allowed to cross with other selected cuttings to produce seed.

Much can be done to improve the present stand in seed gardens now that the various agrotypes have been clearly defined and the value of pubescent leaf shown. The steady de-roguing of trees outside the agrotype being propagated and their replacement by true types, with pubescent leaves if possible, or by tested clones is a necessity in many tea seed gardens.

Seed from the best commercial gardens gives fine results and areas planted with such seed may yield as much as 1,600 lb. tea per acre in the tenth year from planting. Yet with generative clones the yield could be 25 to 50 per cent more than this, together with teas of quality and strength markedly above average.

To revert now to the practical side of seed production, the trees are planted 15 to 20 feet square apart. The Assam and Burma types begin to flower in the second year and may bear seed in the third. Mature trees of the Assam type may yield first class seed at the rate of 400 lb. per acre and the Burma type double this quantity. The addition of fertilizer as sulphate of ammonia up to 4 lb. per tree very greatly increases the yield.

The crop is harvested in Assam from September to November, and the seed pods are collected as they fall although they may be picked just before dehiscence or opening of the pod.

The pods are placed in damp, shallow pits and covered with grass for a few days, after which the shells are easily removed. The seed is then thrown into a water tank, and those which sink

are removed and riddled over $\frac{1}{2}$ -in. mesh. The floaters and the small seed are discarded. A certain number of the sinkers thus sorted out are cracked open and examined for 'stars' and for soundness.

A 'star' is the result of a puncture by the Tea seed bug, *Poecilocoris latus* and actually consists of a small amount of starch left after the bug has extracted its food from the seed. A drop of iodine solution may be placed on the 'star', and if it turns a uniform blue colour it may be assumed that the only damage done to the seed is that resulting from the puncture. If the least part of the 'star' fails to turn blue then a fungus may have entered the puncture. Actually the fungi causing Grey blight, Brown blight and Die-back, and the Eelworm, are the organisms pathogenic to tea which have been found in punctured seed. Neither the fungus causing Blister blight, nor Green fly, has been found. Fusaria, bacteria and moulds are the non-pathogenic organisms found. The best way to ensure sound seed is to control the Tea seed bug, but no effective method has yet been devised.

In addition to punctured seed, some may be unsound because they are mouldy or cheesy and such have usually been lying on the ground for some time. To avoid this, seed is usually collected twice a week during the season.

The seed crop comes in three phases, and of the total harvest about half is sound. In the first and last phase only about a third may be sound. The rest are floaters, small, 'starred', mouldy or cheesy. Tested seed is guaranteed 95 per cent sound in North-East India.

There is still much research needed on the subject of the testing of tea seed. Thus, the floaters are usually reckoned as inferior seed and small seed which passes through $\frac{1}{2}$ -in. mesh is discarded. Yet the size and density of the seed are correlated with *jat* and they are heritable characteristics. In some cases large seed, like small seed, appears to be undesirable.

Seed is usually packed in 40-lb. lots, in dried charcoal or clay or a mixture of both, with a moisture content of about 10 per cent. The germination of tea seed falls off rapidly with time and after a few weeks may be as low as 50 per cent with some varieties.

Nurseries and Planting Out

Since 1932, the area planted to tea in North-East India has risen from about 658,000 to 671,000 acres, an increase of barely 13,000 acres in well over twenty years. Yet during this period, the uprooting and replanting of large areas has proceeded steadily, whilst the infilling or supplying of vacancies caused by the death of bushes has had to be maintained. For these reasons, the planting of nurseries has gone on throughout the period of control of extensions.

It is of interest at this point to consider the question of the longevity of the tea plant and the relationship between this and the rate of replanting. For the first ten years after planting tea, provided the seasons are not too unfavourable and the work has been well done, there are few deaths. Over the next ten years the number of deaths becomes noticeable, whilst between twenty and thirty years the stand often appears to 'hesitate' and many deaths occur. These and earlier failures may be due to the fact that certain of the bushes cannot stand up to root competition, or that their natural root spread is only just below the surface, or that their branching habit makes cut-back pruning which usually takes place in the third decade, a fatal operation or that the natural life span of the particular bush is short. It is common to see an area of tea composed of healthy bushes, well over fifty years old, freely interspersed with vacancies and empty patches, and it is difficult to believe that the bushes which have died ever had the inherent vigour and habits of the survivors. All this links up with the need for careful selection of seed bearers.

In Assam, growing on poor silts, the Assam type of bush may have an economic life of thirty-five to forty years, whilst with the China type it may be over fifty years. It is recommended that the replanting rate of an estate be not less than 2 per cent and preferably $2\frac{1}{2}$ per cent of the total area per annum.

The site of the nursery bed should be near water and near the area to be replanted or infilled. A jungle soil is desirable and the preparation of the land should start in June. If the land is not virgin, a dose of 20 to 30 tons cattle manure, compost or light greenstuff per acre should be hoed in. It is essential that this organic matter be decomposed before the seed is planted at the end of the rains, and this entails an early start in

preparation. The land should be cultivated each month before the seed is sown.

In October, or before the seed arrives, the top soil should be beaten and powdered. When the seed arrives it should be tested as described earlier and the immediate sinkers planted straight away, without germination. The seed which sink after two to four hours may be germinated before planting. The floaters often show such a small percentage of success that planting is not worthwhile. Many planters prefer to germinate all seed before planting, but this may lead to losses since most of the seed germinates at the same time and the ready seed gets ahead of labour, as a result of which rootlets up to $\frac{1}{2}$ in. in length may have grown before planting and these are usually damaged in handling.

The outside of the seed shows a scar of the eye or micropyle through which water enters when the seed begins to germinate. From this point the rootlet appears, and in some estates the seed is planted with the eye downwards in order to avoid a bent or twisted root. This last assumption is open to argument. A twisted root often results from a partially filled seed, whilst a seed planted in a loose, friable soil is capable of wriggling itself the right way up when it germinates. However the planting of the eye downwards connotes close supervision, the ultimate result of which will be good, whatever the exact cause.

The seed beds are 3 to 5 ft. wide, the seeds are usually spaced 6 to 8 in. square or triangular and planted at a depth of $\frac{1}{2}$ in. The best seed germinate within three weeks and with good seed 80 per cent germinate within a month, although the speed of germination, like so many other properties of the tea plant, is heritable and linked with varietal differences.

After the seed is planted, the soil is covered with thatch grass and watered. Later on, overhead shade of thatch supported on bamboo at a height of about 6 ft. is erected. The soil is watered as necessary with an occasional soaking, rather than with a frequent sprinkling. The soil must be kept free from weed growth.

By April the seedlings have produced three or four leaves and then they may be treated with liquid manure. This is made by mixing 80 lb. fresh cattle manure in a 40-gallon drum and leaving it for a few months, with occasional stirring and topping

up with water. Four weekly waterings with the liquid may be given in April. The good result of such treatment may be due to the presence of growth hormones supplied by the cow dung. If liquid manure is not available, Young Tea Mixture, supplying $N/P/K=20/20/60$ lb. per 300 lb. may be applied at the rate of 1 oz. per square yard. In September four more waterings with liquid manure may be given or a further application of fertilizer, if the plants appear to need it.

During the growing season perhaps three flushes, each of five leaves, will be produced by the seedlings and if these are of vigorous growth, the height of the plant will be about $2\frac{1}{2}$ ft. when lifted for planting.

The seedlings are lifted with an unbroken clod or *bheti* in November, which is the best planting month, although the operation may proceed into January. Spring planting often fails. Sometimes for infillings two-year plants are used, and these may be headed back in the nursery by cutting across at 16 in. at the end of the first year and again at 24 in. in the rains of the second year. Although this makes for ease of lifting it is detrimental to root and top growth, as is indeed any form of nursery control.

The average number of seed in a maund (80 lb.) of a good *jat* riddled over $\frac{1}{2}$ -in. mesh, is about 16,000. An acre of nursery can accommodate 3 to 4 mds. seed. About 60 per cent of the seeds sown should produce usable plants, so that a maund of seed should supply 9,600 plants, sufficient for $3\frac{1}{2}$ acres tea planted 4 by 4 feet square, 2,722, plants per acre, or 3 acres hedge planted 5 by $2\frac{1}{2}$ ft., 3,482 plants per acre.

The low proportion of usable plants from a nursery is a reflection to some extent of the assortment of trees used to produce seed. The nursery rejects consist of plants of undesirable variety, poor rooting plants and weaklings.

There is still much discussion as to the ideal planting distance in the field. Some areas have been spaced as wide apart as 6 ft. square, 1,210 plants per acre, and although in due course such planting yields up to the average, the early lean years entail grave losses, especially if the economic life of the bush is only forty years. For 100 per cent cropping efficiency, the yield per acre of soil should be the same as the yield per acre of bush surface. Quality bushes are often not good spreaders and to

make the maximum of such a stand, planting would need to be $3\frac{1}{2}$ by $3\frac{1}{2}$ ft. triangular, 4,120 bushes per acre. A common spacing is 4 by 4 ft. square, 2,722 bushes or triangular, 3,143 bushes per acre.

Hedge planting is at present again under consideration. This was tried in Assam as long ago as 1873, the spacing being 4 by 2 ft., 5,444 plants per acre, but complaints were made that, after some years, in the drought 15 per cent of the bushes died. Trials are now being made with 5 by $2\frac{1}{2}$ ft. planting, 3,482 plants per acre or with double-hedge planting 5 by $2\frac{1}{2}$ by $2\frac{1}{2}$ ft., 5,292 plants per acre. The benefits from hedge planting include an earlier ground cover, less need for infilling since the loss of a single bush is covered by its neighbours, easier pest control, and easier management if mechanization is introduced.

When the seedling with its unbroken *bheti* is taken to the field it must be planted with care and the surrounding soil well tamped down. If available about 10 lb. cattle manure may with advantage be placed round the *bheti*, but not below it or the subsequent dissipation of the organic matter may cause the earth round the young plant to collapse.

In February shade trees should be planted, and in March a semi-permanent green crop as *Boga medeloa*, *Tephrosia candida* or *Crotalaria anagyroides* put out in the rows. If every row is thus planted to green crop, alternate rows should be uprooted after a year. Two or three loppings may be taken each year and left on top of the soil. *Boga medeloa* suffers from Red rust, *Cephalurus parasiticus* attack and should on no account be left in the soil after two years.

The following spring, that is about fifteen months after planting a Young Tea Mixture giving N/P/K=20/20/60 lb. per acre composed of 100 lb. sulphate of ammonia, 100 lb. superphosphate and 100 lb. muriate of potash should be applied. This dose may be repeated the following year, after which sulphate of ammonia only need be given. The time-table of planting tea, the yearly operations needed and the crop expected is summarized in the next section.

Finally, mention may be made of the need or otherwise for a fallow year between uprooting and the replanting of tea. If a fallow is employed, the soil should be sown with *Boga medeloa* or *Crotalaria* broadcast in the spring. If there is no fallow year,

and one is not actually necessary, the old tea should be left unpruned and plucked 'black' till June, when it is uprooted and prepared for planting in November.

Pruning

The scientific study of the pruning of the tea bush in Assam began about 1920 and was developed in line with fertilizing. Earlier than this, when a bush looked debilitated it was considered to need drastic pruning, whereas what it really needed was more food.

In 1860 the only pruning done was the removal of dead wood with a bill-hook and occasional trimming with garden shears. About 1870 centring was advocated, whilst pruning saws and pruning knives were introduced. Soon after this it was realized that a narrow bush full of twigs in the centre needs nourishment, but it was still thought that matters could be put right by corrective treatment which consisted in heavy pruning. In 1900 heavy pruning was considered a necessary evil and this idea persisted for many years, for between 1920 and 1930 extensive areas of mature tea in Assam, both good and poor, were collar-pruned. Up to 50 per cent of the bushes died over the following decade and many survivors still carry cankered boles, so that under the strain of drought or disease they shut up and cease to yield. It is true that the tea bush needs the stimulus of pruning, otherwise many shoots remain in the dormant stage and crop falls, but top-pruning and manuring can give all the stimulus required.

Close study of all phases of pruning has been made at Tocklai, and today tea is never collar-pruned and rarely heavily pruned. Procedure is practically standardized. Young tea, one-year after planting, is cut across at 18 in. from the ground and lightly centred in December which is the best month for pruning. The bush is then allowed to grow to 30 to 36 in. which height is reached about the following June, when it is tipped at this height and then plucked level. The next year the bush may be left unpruned and again plucked level. Subsequent top prunings are at 20, 22, 23, $23\frac{1}{2}$ in. and so on, thereafter rising by $\frac{1}{2}$ in. each year. After 25 years or so the bush may be too high for plucking and it is then medium-pruned back to 24 to 28 in., after which the pruning height again rises $\frac{1}{2}$ -in. each year.

After about forty years the area is due for uprooting and replanting, without ever having been hard pruned.

Recent experiment has shown that when tea is cut back at different heights from the collar to 28 in., at 4-in. intervals, the loss in crop over the next five years is directly proportional to the height of the initial prune below 24 in. Of the bushes collar-pruned 25 per cent die, and deaths from other cuts are directly proportional to the severity of the cut.

It has been shown that the best time to prune is November and December and delay after that period entails serious loss of crop and a reduction in the second flush teas.

In Assam there is little difference in yield between tea pruned annually and biennially. The benefit from unpruned tea comes from the fact that the cropping period of the whole estate is appreciably lengthened if a half or a third of the tea is left unpruned, and this better distribution is an advantage if labour is short. The unpruned areas give an early crop and close down early.

It has been customary in the past to rest debilitated areas by leaving them unplucked from August onwards, or letting them run for one or two whole seasons unplucked. These procedures all lose crop in the following years, and it is suggested that a better way to increase the vigour of a bush is to pluck it lightly. Rested or unplucked tea grows well in the centre of the bush, but at the expense of the sides which seem to atrophy and a narrow bush is so formed.

With regard to the cleaning out of bushes which are top-pruned, experiment has shown that the removal of dead wood does not increase the yield, but the removal of *bhanji* shoots markedly increases crop, especially on tea annually pruned. Spacing and stick pruning both reduce the crop.

In the table below, the treatment of young tea with regard to pruning and plucking is shown, together with the expected crop when the stand is adequately fertilized.

<i>Year</i>	<i>Operation</i>	<i>Manure per acre</i>	<i>Crop per acre</i>
1	Nursery, November to November	Liquid manure	nil
2	Plant, in November	.10 lb. Cattle per bush Green crop	nil

<i>Year</i>	<i>Operation</i>	<i>Manure per acre</i>	<i>Crop per acre</i>
3	Cut across in November 18 in. Pluck 30 to 36 in.	N/P/K=20/20/60 lb. Green crop	120 lb. tea, (1½ mds.)
4	Unpruned. Pluck 30 to 36 in.	N/P/K=20/20/60 lb.	480 lb. tea, (6 mds.)
5	Prune 18 in. Pluck 28 in.	40 lb. N	720 lb. tea, (9 mds.)
6	Prune 20 in. Pluck 28 in.	50 lb. N	960 lb. tea, (12 mds.)
7	Unpruned. Pluck 28 in.	60 lb. N	1,200 lb. tea, (15 mds.)
8	Prune 22 in. Pluck 28 in.	70 lb. N	1,440 lb. tea, (18 mds.)
9	Prune 23 in. Pluck 29 in.	80 lb. N	1,600 lb. tea, (20 mds.)

As the canopy of leguminous shade trees develops, the addition of nitrogen may be reduced or discontinued from about the seventh year.

A study of the above table will show that if tea giving a crop of 10 mds. per acre, which outturn is now uneconomic in many Assam districts, be uprooted and replanted, the new tea under modern treatment can in about seven years make up the loss in yield incurred by uprooting.

Plucking

The earliest planters in Assam used the Chinese method of plucking the tea bush, whereby all the growth of the flush was taken at a plucking. In this way the first plucking left the bush denuded of young leaf, as did each subsequent three or four plucks. In 1853 Geo. Williamson, then Manager of the Assam Company, left leaf on the bush before plucking in the spring thereby forgoing most of the first flush and losing early crop. This loss was more than made up in later pluckings. From that time argument arose as to how much spring leaf to leave and it is still difficult to give a concise answer to this question.

The early planters, still following Chinese methods, often plucked the buds separately in order to make Pekoe, whilst even in 1900 it was common to take half leaves, leaving the axil below the half leaf to produce a shoot. In 1920 it was customary on many estates to pluck the bush to an umbrella-shape top, on the assumption that the convex plucking surface gave

more leaf than a flat one. Experiment then in hand soon convinced the industry that, both for ease of supervision and for crop, a flat plucking surface paid. The umbrella-shape surface resulted from the habit of plucking not to a height above the ground or above the top-pruning but above so-many leaves, for in the centre of the bush the distance between leaves may be 2 in., whilst at the sides it is often less than 1 in. Thus the bush at the centre rose more than at its sides.

After much experiment it has been decided that bushes should never be plucked below about 28 in. from the ground, and not less than 6 in. new growth should be allowed above top-pruning level before tipping. With weak tea it may pay to leave 8 in. new growth before tipping starts. All these measurements refer to the Shan and Burma types of bush.

It takes four to five days for a leaf to unfold and open from the bud in Assam, and a plucking round every four or seven days fits in well with this rate of growth and calls for the minimum of 'breaking-back' of overgrown shoots to the level of the plucking table. This operation is desirable in that it makes supervision easier. A weekly plucking round is aimed at on most estates.

Shoots which are *bhanji* (resting) must be plucked or crop will be lost. In a fine pluck in Assam the *bhanji* shoots may equal 20 per cent of the total.

In Assam the first flush begins early in January and continues over about 105 days. The second flush begins in mid-April and extends over about eighty days, and the third early in July and extends over eighty-five days. The fourth flush begins at the end of September and extends over fifty days, whilst the fifth and last flush begins in mid-November and lasts for forty-five days.

The first, second and third flushes are easily recognized, but the crop curve shows no marked indication of the fourth flush. Most of the first flush is left on the bush to make up the first 6 or 8 in. growth which is allowed before tipping takes place. The second flush constitutes a little over one-fifth of the total crop.

The proportion which the various parts of the shoot form of the whole shoot is shown below for fine and coarse plucking. It takes no less than 1,800 fine shoots to make 1 lb. tea.

	<i>Two leaves and a bud</i>	<i>Three leaves and a bud</i>
	%	%
Bud . . .	14	7
First leaf . . .	24	12
Second leaf . . .	45	24
Third leaf . . .	—	33
Stem . . .	17	24

Although three leaves and a bud weigh about double two and a bud, the extra crop gained by coarse plucking is only about 50 per cent above fine plucking. It might be thought that when coarse leaf is plucked, the fine parts could be sorted out after rolling and fine tea still made, with the coarse parts making up the Souchong grades. This is not possible however, because in rolling much of the coarse leaf is broken and green sifted out mixed with the fine leaf. To make fine tea, fine leaf must be plucked.

Cultivation

In 1870 the advice given to Assam planters regarding cultivation was to dig the whole garden three times a year and bury weeds in trenches, to dig round the bushes once a month and to use the Dutch hoe as often as weeds appear.

Planters have always recognized the harm done by weeds especially to young tea, and have known that thatch grass can stifle mature tea. But for many years it was also believed that soil stirring, as such, was good and cultivation or 'tincture of steel', as it was popularly designated, was the first consideration in garden operations. If the bushes 'sulked', then two rounds of hoeing at short intervals were advised. Perfectly clean soils were often cultivated.

In 1925 these ideas still held and tea was sometimes planted in widely separated hedges so that, when it became available, a mechanical cultivator could work between the rows. The hoe with a long handle was used for cultivation, and each cold weather a deep hoe, aiming at 9 in., was given. Up to one-third of the estate each year was trenched in alternate lines to 18 in. A light hoe to a depth of 5 in. each month was considered ideal, but few estates achieved this degree of soil disturbance and five to seven rounds was the average. On the other hand, in 1925, on an estate in Cachar, with one area

planted on a clay flat and giving the enormous yield of 3,200 lb. tea per acre, the bushes so closely covered the soil that it was not touched with a hoe for three years. The dense cover of tea controlled weed growth.

In 1922 cultivation experiments were started at Tocklai, Assam, and within a few years it was evident that soil disturbance increases yield only if it suppresses weed growth, and that beyond this it is wasted effort. It followed that if the tea bush can be made to cover the ground adequately and suppress the weeds beneath, then cultivation is unnecessary. In practice this last seldom happens and some weed control is generally needed.

As a result of these observations, trenching and deep hoeing ceased in the tea estates in North-East India whilst light hoeing soon gave way to the scrape, given by a *cheel* hoe. This implement has a blade 10 in. broad, half-moon shape, set at an acute angle to the shaft, so that it cannot be swung as the hoe but only used as a scraper.

It has also been shown in North-East India that the burying of organic matter, be it cattle manure, green crop or prunings, has no advantage over leaving it on the soil surface. The burying of artificial manures likewise brings no advantage.

Much of the weed growth in tea estates is in the form of grasses, especially thatch grass and Nagapat both of which are monocotyledons, so that selective weed-killers like 2,4-D and 2,4,5-T are of little use for weed control in tea. Grasses suppress soil nitrification but tea can absorb applied nitrogen, given as sulphate of ammonia, even in the presence of grasses.

On most tea estates, the programme of cultivation includes one round of *kurpi* or *thully* in which the soil round the bole of the bush is cleared of ferns and mosses. This treatment is given about February and also acts as some control of insect pests, for the stirring of the soil disturbs chrysalids. One round of *cheel*-ing is given in the spring, and three or four rounds of sickling of the weeds through the monsoon.

At one time most estates in North-East India were drained by 3-ft. drains dug about 40 ft. apart, but then came a period when drains fell into disuse and were allowed to fill-in. Recently however, interest in drainage is again becoming evident, but though the subject is certainly of importance in some areas it does not present problems in many estates.

Manuring

The systematic manuring of tea in North-East India is a comparatively recent innovation. As early as 1870 the value of cattle manure for tea was realized by some planters whilst the soil from *nullahs* and *bheels* was used as top dressing. Arguments used against manures were based on expense and also on the opinion that once used, it became necessary to continue to use them. The Chinese argument that manures spoilt the quality of black tea was also put forward.

By 1900 a good deal was known about manures for tea. Green crops, leguminous shade trees and bushes, oil-cakes, bones and wood ashes were used, and most of the chemical fertilizers employed today were often spread as mixtures. The precise danger of using sulphate of ammonia, in that it leaches out lime and potash from the soil, was fully appreciated, with analytical figures in support. The manurial rotations recommended at this period seem very meagre by present standards. Thus one seven-year rotation included 5 tons cattle manure in one year, 4 cwt. basic slag in another, two eight-week green crops and one sowing of mustard in three other seasons, and two blank years. The Assam crop at this time averaged 5 mds. (400 lb.) per acre.

Systematic manuring as a general rule in estates began about 1920 and at the same time a wide range of manurial experiments were started at Tocklai. The five-year rotation then suggested was as follows. Lime and cattle manure/phosphates and cowpeas/N and K mixture/phosphates and Boga medeloa sown/mixture and Boga medeloa trenched in. The lime application consisted of 10 mds. (800 lb.) crushed limestone with 5 tons cattle manure. Next year 40 lb. phosphoric acid was given and the following year 30 lb. nitrogen and 20 lb. potash. In the Boga medeloa year 40 lb. phosphoric acid was again given, whilst in the fifth the same mixture as in the third was applied.

In 1925 it was shown that lime depresses the tea crop in Assam, and soon after it was observed that no gain in yield resulted from growing and burying an 8-week green crop. Over these years pruning and other field works were improving and it was soon evident that with a tea bush of wide spread, Boga medeloa did not grow satisfactorily in the lines. Thus,

step by step, the use of nothing but chemical manures became the rule. Some estates tried to use only organic manures like Sterilized Animal Meal and oil-cakes on the assumption that such maintained quality in the tea and did not interfere with the chemistry of the soil. Other estates relied wholly on shade trees to maintain soil fertility.

The make-up of the fertilizer mixture also changed as experimental evidence accumulated. At first, one giving N/P/K=30/30/30 lb. per acre was employed, consisting of sulphate of ammonia, superphosphate and muriate of potash. Then it was recorded that neither potash nor phosphoric acid increased the crop, whilst the increase from nitrogen went on steadily till the dose reached 80 lb. N per acre, at which rate after four annual applications the crop increase is 8 mds. (640 lb.). From 80 lb. to 120 lb. N per acre the increase continues at a slower rate but at one still highly profitable. The increase curve finally tails off at doses of about 160 lb. N per acre. Today many estates regularly apply 400 lb. sulphate of ammonia per acre giving 84 lb. nitrogen.

All the usual artificials have been tried in experiment. Nitrate of soda works well for a year or so, but then harms the soil tilth and gains a poor crop response. Calcium cyanamide has been used to balance the increase in soil acidity and leaching out of lime due to the addition of sulphate of ammonia, but as a fertilizer it never became popular. Sulphate of potash gives the same result as muriate. Superphosphate gives no increase of crop, except with tea under leguminous shade trees. Artificials can be applied at any time during the year, but they must be added by June if the full benefit of increased crop is to be realized that year. The most suitable time for application is in the slack period of March.

If tea is planted on virgin soil in Assam, the crop at the end of about ten years will be 800 to 1,000 lb. per acre. Then, unless fertilizers are applied, it will fall steadily to perhaps 600 lb. per acre at which it will remain. If such tea is given 80 lb. N per annum, the crop in four years will reach about 1,240 lb. per acre, but if the manurial dose be then omitted the crop will decline steeply towards 600 lb. again, for although a large bush has been developed by the previous manurial treatment, the incentive to flush is missing. Cattle manure or organic manures

appear to last longer, but only because their nitrogen is yielded up more slowly. Whatever the source of nitrogen, the bush appears to gorge it as available and to utilize it mainly over the same season.

A crop of 1,000 lb. tea removes from the soil about 50 lb. nitrogen, 25 lb. potash, 8 lb. phosphoric acid and smaller quantities of other minerals. Nitrogen can be replaced by leguminous shade trees or green crops, certain soil algae appear to fix nitrogen from the air, and rainfall adds a certain quantity of nitrogen in the form of nitrates and ammonia. But the potash, phosphoric acid and other minerals can only be replaced in the soil by additions brought in from outside, or by the natural weathering of the soil minerals. The last process is known to be extremely slow and a time may come when there is neither sufficient potash nor phosphoric acid in a soluble, available form for the tea plant, but that time is not yet. It might be suggested that superphosphate and muriate of potash be added now for future use when required. However, it is known that both substances soon become insoluble and non-available in the soil, hence a reserve build-up of available mineral food is not practicable.

The problem of fertilizing tea is closely bound up with the growth of leguminous shade trees amongst the tea. As far back as 1875 Colonel Hannay in Dibrugarh drew attention to the sau tree, *Albizzia stipulata* which he called the 'tea fertilizing tree' under which the tea flourished and flushed well. Since that time a number of leguminous trees have been used in tea, but it was not realized till about 1935 that under such shade, sulphate of ammonia seemed to lose much of its power to increase the crop. In 1940 shade tree experiments were laid out at Tocklai and after ten years the analysis of the results produced astounding facts.

Several trees were tried out, including both the green and red stipuled *Albizzia stipulata*, sau or kala siris, the *A. odoratissima*, kakor siris, the *A. procera*, koroï or safed siris, the *Dalbergia assamica*, bor medeloa and the *Derris robusta*. In addition the non-leguminous tung-oil tree, *Aleurites montana* was used. The most efficient trees, giving the greatest increase in crop were the two types of *A. stipulata* and the *A. odoratissima*, whilst the only inefficient tree was the non-leguminous tung.

The sau tree is very liable to canker and may die in under ten years in North-East India, a fact which makes the kakor siris, *A. odoratissima* the most important shade at present. Experiment has shown that if these trees are planted 40 by 40 ft. amongst the tea, within seven to ten years they are able to increase the crop by as much as is realized by the addition of 80 to 100 lb. N given as sulphate of ammonia. Such shade reduces the light intensity to about half that in full sunlight.

The beneficial effects of shade trees come from a number of factors. Thus they reduce the sunlight, lower the maximum day temperature and raise the minimum night temperature, raise the relative humidity of the air and, by reducing air movement, increase the concentration of carbonic acid gas in the air near the soil. All these factors make for increased flushing compared with conditions in full sunlight. In addition each tree by its leaf fall and from its roots possibly adds 3 to 4 lb. N to the soil, which totals 75 to 100 lb. N per acre with a tree population of twenty-seven per acre.

What is still more interesting about shade trees planted amongst tea as above is that sulphate of ammonia has its efficiency in increasing the tea crop reduced to about one-half that in full sunlight. One explanation of this is that the bushes are so gorged with nitrogen gained indirectly from the shade tree droppings that they can take up little more from the sulphate of ammonia.

Coming now to the question of mineral plant foods, deep rooting shade trees can be expected to bring up potash and phosphates from below the roots of the tea plant, whereby the problem of the depletion of the soil of mineral food is postponed for many years. The planting of shade trees amongst the tea would appear to solve for the present some of the fundamental problems of soil management in the tea estates in North-East India.

Pests and Diseases

For the past fifty-odd years the life histories of the pests attacking the tea bush have been studied and worked out. Over the same period the fungi causing the various leaf, stem and root diseases have also received close attention. Since 1935 the development of new insecticides, like D.D.T. and gammexane,

and the introduction of special copper solutions, combined with more effective dusting and spraying apparatus than was previously available, has given the industry much more effective control of pests and diseases than before.

Work on diseases has been given the name of plant pathology, whilst mycology denotes the study of the fungus forms but not the diseases they cause. The knowledge on tea diseases has rapidly been extended over recent years, as has the study of entomology, connected with insect pests, and the study continues. Apart from root diseases the five commonest pests and diseases of tea in North-East India are as follows:

1. Red spider, *Metatetranychus bioculatus* attacks mature leaves in April and persists till the monsoon. The control of this pest is still under study. A Lime-sulphur spray effects some control as does defoliation after pruning.

2. Tea mosquito, *Helopeltis theivora* attacks the flush from September till the end of the season. Control is effected by D.D.T. spraying in June/July or September/October.

3. Blister blight, caused by the fungus *Exobasidium vexans* attacks the young leaves in the cold weather and may seriously damage cut-back tea. The fungus is an obligate parasite and having killed the leaf then dies. The attack persists in shady places and is worst in a dull year. Control is obtained by spraying with Perenox, a copper spray.

4. Black rot, caused by the fungus *Corticium invisum* attacks in warm, dull weather and is controlled by Perenox or Burgundy mixture spray.

5. Red rust, due to *Cephalurus parasiticus* is common on young tea, producing orange patches on the stems. Boga medeloa also suffers from this disease. Spraying with Lime-sulphur or a copper spray as Burgundy mixture or Perenox, effects some control.

Gammexane is a useful spray but it cannot be used on tea because of the taint it leaves even three weeks after use. An odourless variety is said to be in preparation.

There are several root diseases which give much trouble because their presence is only realized when the bush suddenly dies, often at the end of the season. Unless the affected bush is then uprooted thoroughly there is little chance of arresting the spread of the disease to neighbouring bushes. There are two

common primary diseases which attack a bush whether it is vigorous or not. These are Charcoal Stump Rot, *Ustulina zonata* and Brown Root Rot, *Fomes noxius*. Two common secondary root diseases are Violet Root Rot, *Sphaerostilbe repens* which attacks waterlogged bushes, and Diplodia, *Botryodiplodia theobromae* which often occurs on very sandy soils. There is no royal road yet to dealing with root diseases and in some estates control of such is a major field problem.

CHAPTER XI

TEA MANUFACTURE IN NORTH-EAST INDIA

The layout of a tea factory—Power, machinery and equipment—The withering of tea leaf—No-wither and cut-leaf teas—Rolling—Fermentation—Drying or firing—Sorting—General conclusions.

IN giving an account of tea manufacture in North-East India, the procedure commonly followed, producing the kind of outturn to which tea drinkers are accustomed, is described. The development of tea machinery and equipment is outlined and the various devices invented to simplify or to hasten the process are indicated.

During the manufacture of black tea biochemical changes take place, starting immediately after plucking and proceeding during withering. When the leaf juices are exposed to the air after rolling, other changes are initiated, which are more obvious than those occurring in withering, and these are stopped after two or three hours by heat and drying. All these reactions are capable of variations which depend on time, temperature, the nature of the cell distortion and the concentration and composition of the leaf juices. The wither, both physical and chemical, controls the last two factors.

Good tea can be made over a wide range of conditions, whilst temperatures and times can to some extent be adjusted nicely to produce the best possible mixture of soluble substances in the tea commensurate with the inherent qualities of the leaf. But there are limits beyond which neither temperature nor time may be extended if the best is to be made of the pluck.

In spite of the fact that the range of conditions for making the best of the leaf is well known, whilst rapidly accumulating chemical knowledge explains why these conditions are necessary, experiments outside the safe range are frequently made, with inevitable failure.

The Layout of a Tea Factory

Tea factories in Assam are lofty, single-storied buildings, with one or more withering sheds situated nearby. Modern factories are constructed of iron, with corrugated iron roofs and cement floors. The size of a factory varies according to the outturn of the estate, and for a 1-million lb. (12,500 mds.) crop the main building may be 200 ft. long and 80 ft. wide. Offices, stores and withering sheds go to make up the impressive group of buildings which occupy the factory compound.

In Darjeeling, factories usually have two or three stories, the upper ones used as withering lofts. Many factories in the Dooars and the Surma Valley have lofts above the main building although outside sheds are also employed.

The ground floor of a tea factory consists essentially of three divisions, the rolling, firing and sorting rooms. Sometimes the leaf is fermented in an extension to the rolling room, but usually the rolled leaf is transported to a fermenting room situated below a withering shed, which arrangement ensures a certain degree of coolness not easily obtainable in the main factory building.

The firing room is generally situated in the middle section of the factory, separated from the rolling room by a thick wall to prevent the latter from getting too hot. In the firing room there may be three or four dryers, each emitting up to 12,000 cu. ft. of air per minute at 120° F. whilst the dryers themselves radiate heat. Hence, in spite of ventilation and the ducting of exhaust air, the firing room is usually hot.

The section where the sorting takes place includes not only the sorting machinery itself, but also the bins for storing the grades till a break is accumulated, the bulking floor, the packing machinery and the despatching section.

The power unit is sometimes housed in a separate section adjoining the main building. Most factories have been extended from time to time, and are thus not always as conveniently arranged as could be wished.

Power, Machinery and Equipment

Power is required to turn the rollers, to work the fans and trays of the firing machines, to run the sorting machines and

the plant for generating electricity. Steam and oil engines are generally used to supply the power which is transmitted by shafting and belting to the individual machines. In some cases suction gas engines, Pelton wheels and water turbines are used, although the irregularity of the water supply before June necessitates standby engines with the last two plants. There are as yet no big hydro-electric schemes in North-East India from which power can be purchased. In rare cases, oil engines are used to generate electricity which is the power for the factory.

A tea roller takes about $1\frac{3}{4}$ H.P. running empty, 4 to 5 H.P. when rolling leaf without pressure, and with pressure 8 to 14 H.P. according to the leaf charge and the heaviness of the pressure. A 6-ft. tea dryer takes 5 to 10 H.P. to run according to the model, most of which is required to drive the fan as the power taken for the trays is small. The power to drive the sifting machines, packers, dynamo, etc. may be covered roughly by 10 H.P.

It is now proposed to calculate the factory requirements for a 10,000-md. crop in Assam and, in so doing, it is assumed that 75 per cent of the crop is harvested from July to October. With twenty-six working days a month it will be seen that an average of $\frac{3}{4}$ per cent of the total crop, which is 75 mds. tea, will be made daily over that period. In the Dooars and Surma Valley, although the rush period is more concentrated than in Assam, the use of large areas of unpruned tea, often one-third of the estate, lengthens the cropping season and reduces the rush. Hence in these two districts it is still reasonable to legislate for a daily outturn of $\frac{3}{4}$ per cent of the total crop.

Assuming that leaf is spread on the withering space at 1 lb. per 9 sq. ft., then 75 mds. tea, made from 333 mds. green leaf or 26,640 lb. leaf, require about 240,000 sq. ft. of withering space. If this amount of space is available then day-in, day-out space for reasonable spreading is possible, even in marked rush periods.

So far as rollers are concerned, the norm for rolling in North-East India is two half-hour periods. If the wither is to 70 per cent (100 lb. leaf dried to 70 lb.) the initial roll charge $3\frac{1}{2}$ mds. leaf (280 lb.) and ten minutes are allowed between the first and second rolls for cleaning and recharging, then eight 36-in. rollers can deal with the withered leaf to make $6\frac{1}{2}$ mds. tea per

hour. Thus in twelve hours, the average day's make can be dealt with. If the day's pluck produces much more than the average, sufficient leaf to make perhaps 100 mds. tea, this leaf can be rolled in sixteen hours, a double shift. If the wither is not as full as 70 per cent, the extra leaf may be accommodated by using a heavier initial charge, although this may involve a slightly higher temperature in the leaf bulk and some loss of quality and strength if temperatures rise above 80° F.

From the above, since eight rollers can deal with a 10,000-md. crop, it may be deduced that for each 1,250 mds. tea made one 36-in. roller is needed.

Regarding fermenting space, a roller charge of 280 lb. leaf spread at 1½ in. thick occupies about 100 sq. ft. Since the leaf is spread for only two and half hours, the same space can be used four or five times a day, although this is not recommended owing to the danger of bacterial infection as the day proceeds. If the same space be used only twice a day, 3,000 sq. ft. should be ample for a 10,000-md. crop.

In calculating the firing equipment for a 10,000-md. crop it is assumed that a double fire is given, the first with an initial temperature of 200° F. for twenty-five minutes and the second at 180° for fifteen minutes. Under these conditions a 6-ft. and a 4-ft. machine of the older type working together can handle about 4 mds. tea per hour. Hence to dry about 75 mds. tea in a day, two 6-ft. and two 4-ft. dryers will deal with the outturn in about nine and a half hours. On the biggest days, when 100 mds. may be made, the firing period will extend over twelve to thirteen hours.

Thus, to summarize, it may be stated that a crop of 10,000 mds. tea requires eight rollers, two 6-ft. and two 4-ft. dryers. The total power required to run all the machines at peak load would be about 130 H.P. although in practice not more than 80 to 90 H.P. are required at any time.

The Withering of Tea Leaf

As the leaf is plucked on the estate it is put into a basket by the plucker and in due course carried to the weighing shed at the end of the morning. The afternoon's pluck is weighed at the end of the day's work. The pluckers are paid according to weight of leaf gathered.

When leaf is pressed tightly into the basket it gets hot and turns red. Temperatures of 120° F. and higher are common if leaf has been tightly packed for two or three hours. Leaf which has been kept at 130° even for twenty minutes turns red, is killed and fails to ferment. Hence much trouble is taken to avoid so-called 'red leaf'. It is becoming customary in some districts to collect the leaf in a cloth instead of in a basket, since tight packing is less likely in the former.

When the weighed leaf is brought in, it is spread for withering. In Assam the *chung* type of shed is used, consisting of a series of floors, 2½ ft. apart, composed of split bamboo or wide-mesh wire covered with hessian. Bamboo has the disadvantage of being attacked by insects and, as it disintegrates, powder falls on the leaf below and may cause taints in the tea. The leaf house, as it is called, may be 25 ft. high, 150 ft. long and not more than 40 ft. wide. It must be placed on an airy site near the factory.

In the Dooars and the Surma Valley ½-in. wire mesh racks are used, 1 yd. wide, 5 in. apart and with a rake of one in three. The banks of double racks are about 6½ ft. high, and the distance between banks is 2½ ft. This type of shed is cheaper and more effective than the *chung*. Exhaustive experiment over long periods has shown that there is no difference in the appearance or liquors of the teas made in the two types of shed.

The period of the wither is about eighteen hours, which suits the estate organization. Thus the leaf weighed and spread at noon is ready to be rolled by about 6 a.m. the next day, and manufacture starts then and proceeds till about noon. By that time the previous evening's weighment of leaf is ready for rolling. Properly withered leaf has a 'kid-glove' feel, and the stems of such shoots may be bent double without cracking. This last test is used in China and was passed on to the planter in the early days of tea in Assam.

As described in previous chapters, the limping or withering process as practised in China is suited to the small farmer with only a few pounds of leaf to handle. With great quantities of leaf, the Assam planter first used bamboo trays in sheds, then bamboo racks, followed by the *chung* and the wire rack. Leaf houses are expensive to build, whilst the spreading and collecting of leaf takes much labour. The bother and expense of the

wither was realized at a very early date and in 1830 Jacobson, founder of the tea industry in Java, invented a withering machine consisting of a long hexagonal box which was filled with leaf and rotated whilst hot air was pumped into the box. In 1908 Bosscha, also in Java, patented another limping machine which was a long hexagonal wire cage in which partially withered leaf was finished off with air at 92° F. for one hour.

The inventors of the early dryers claimed that their machines could be used for limping the leaf if necessary. Before 1900 various hot air chambers were patented, including one by S.C. Davidson using warm moist air at 90° to 100° F. In 1927 Messrs. Marshall's produced a machine resembling an over-sized dryer in which partially withered leaf was treated for thirty minutes at 100° . All these failed or were not successful enough for general adoption.

But research into the problem of obtaining a rapid wither continues. It is reckoned that the chemical wither needs up to eighteen hours to develop. The physical wither must be carried out reasonably slowly if it is to be even throughout the shoot. It has been shown that a temperature of 130° F. practically kills the leaf in twenty minutes and stops all fermentation. Even at a temperature of 100° for two hours the wither is uneven, although the fermentation when the leaf is subsequently rolled is apparently normal, but the infusion is duller than with leaf not submitted to such a temperature. Hence the limits between which any wind tunnel, withering box or drum must work are being narrowed and indications suggest the use of temperatures well below 100° and a time much longer than two hours. The logical conclusion to this problem is the withering loft as developed in Ceylon and South India, where temperatures below 80° F. are used and times up to eighteen hours or more.

A number of lofts on the Ceylon plan have been built in Assam and the Dooars, but none have succeeded sufficiently to warrant duplication. This is because the atmospheric temperature in North-East India during the rains is between 80° and 90° F. and when such air is heated to enhance its drying power in the loft, temperatures well above 90° result and quality in the leaf is lost. To avoid this defect, the Ceylon loft has been adapted, both in Assam and the Dooars, to use air which has

been dried over silica-gel before being sent, unwarmed into the lofts. Here again, for some reason, the system has not been successful enough to warrant general adoption.

Withering drums and wind tunnels are now under experiment in India, Ceylon and Africa. The need for time in which to develop the chemical wither is recognized, and it is proposed to hold over the leaf for twelve to eighteen hours for this purpose, and then to use the tunnel or drum for two to four hours to help the physical wither. This order of procedure is desirable because, if the physical wither is obtained when the leaf is first brought in, the handling of such leaf in spreading for the hold-over starts fermentation and produces dull teas. The tunnel or drum may be used to supplement the leaf shed on days when the natural wither is poor.

Mention may here be made of the Mobile-tat system of withering used in some estates in East Africa, which is the ultimate development of the withering drum or wind tunnel, with the Ceylon loft system of air movement applied. The system comprises a large number of separate banks of racks or tats, the latter very closely arranged, hung from an overhead rail. Each bank is run to the spreading place where, by a simple arrangement, the individual racks are spread with leaf and then hooked up into the bank. As each bank is charged it is railed off to the air chamber where it is marshalled closely against other banks. The chamber is completely occupied by banks of tats and air is sent through, first directly then in reverse. The Mobile-tat is worthy of fuller consideration.

Other methods of limping the leaf in order to make it fit for rolling have been tried. Thus, leaf has been suddenly submitted to reduced air pressure to make it limp. If leaf is frozen or chilled, it becomes limp when it warms up again in the air. Both these systems have been under experiment in Africa, but have not been developed.

At present in North-East India, with the exception of the Darjeeling district where controlled lofts are used, wire racks in open-air sheds give the most satisfactory service.

No-wither and Cut-leaf Teas

Many factories in North-East India are short of withering space, indeed in a steadily expanding industry like tea there is

usually a chronic shortage of most factory equipment. In addition to this, it is often difficult to wither the leaf naturally because of the humid atmosphere, however much rack space is available. In Upper Assam, most favoured of tea districts, there are probably up to fourteen days of the season when it is impossible to get even a light physical wither. In the Dooars and the Surma Valley bad withering days are more frequent.

Unwithered leaf is difficult to roll and instead of taking on a twist it is smashed into flakes and forms a mash. In order to make the rolling of such leaf more effective, a Cachar factory in 1923 first put the turgid leaf through a chaff-cutter which turned out strips of leaf up to 1 in. wide. The cut leaf did not spill badly between the roller box and the table, as does unwithered, uncut leaf, and fair damage was done to the leaf cells in rolling. From the use of the chaff-cutter it was a natural step to the tobacco-cutter, which was tried in the Dooars about 1925 with great success.

The machine in common use today is the Legg Cutter, originally designed for cutting tobacco. It compresses the leaf into a firm cake and whilst in this condition cuts it into strips with mathematical precision. According to the setting, the strips vary from $\frac{1}{4}$ to $\frac{1}{100}$ in. After cutting, the leaf is given a short, light roll, a short fermentation and is then briskly fired.

When the tobacco-cutter was first used, the cut was $\frac{1}{4}$ in. The cut leaf was rolled for half an hour and such treatment produced 60 per cent B.O.P. with the rest of the outturn mainly Fannings and Dust. As the process was developed, a narrower cut was used and in due course up to $\frac{1}{64}$ in. was employed, thereby producing 80 per cent Fannings and over 15 per cent Dust.

About 1930, the idea gained credence that the withering process was not necessary or was indeed harmful. As a result it became the aim in some factories making cut-leaf teas to manufacture as soon as practicable after plucking. At this stage it is desirable to consider the theoretical aspect of the procedure.

The tea leaf is about $\frac{1}{100}$ in. thick, and the individual cells are about $\frac{1}{1000}$ inch across. If unwithered, turgid leaf is cut at $\frac{1}{64}$ inch, most of the cells are either broken or distorted especially when the knife is getting blunt.

In the normal rolling process, the cells in the withered leaf

are, in the main, distorted but not broken, and it will be safe to assume that, under these conditions, oxidation will be slower than when turgid, unwithered leaf is tobacco-cut whereby much of the damage is done at the moment of cutting. Experience has shown that whereas rolled, withered leaf ferments in about three hours, cut turgid leaf needs only half that time.

Experience with the tobacco-cutter has shown that the cut should not be closer than $\frac{1}{32}$ in. The cutting blade must be kept sharp, for a blunt blade damages too many cells, and also exposes stalk. The cut leaf should be rolled in a machine with a flat table and no battens, but fitted with a cone, stud or pillar in the centre. No pressure cap is used, in fact pressure forces the leaf out of the roller, between box and table.

Unwithered tobacco-cut teas give bright infusions and liquors with colour and strength, but they are often 'brassy' or raw. Quality is not developed because of the lack of wither. The speed of fermentation of these teas is so rapid that over-fermentation easily takes place, especially above 80° F. which is the critical temperature in fermentation.

The advantages claimed for non-wither teas include the saving in withering accommodation, although this may be balanced against the extra cost of firing which is half as much again as with normal manufacture in which the leaf is withered. There is no saving in machinery for rollers are still needed whilst tobacco-cutters and more dryers have to be installed. The actual saving in labour for withering is less than $\frac{1}{10}d.$ per pound of tea. The benefits from the process include the production of bright, strong teas of the Fannings type, although the appearance of the leaf is brown and flaky. It is estimated that at present about 60 million lb. no-wither teas are produced annually in North-East India.

The Rolling of Tea Leaf

The first attempt to hasten the hand-rolling process in Assam came from J. Nelson, a Cachar planter who filled a bag or bolster with leaf and rolled it on a table by means of a box weighted with stones. This procedure aimed at preparing the leaf for hand rolling, 80 lb. being made ready in fifteen minutes, with the result that such leaf could be finished by hand in a quarter of the time normally taken. Other inventors also

produced a bag type of roller and W. S. Lyle of Dibrugarh patented a machine in 1874 in which bags were rolled in the annular space between a drum and a cylinder.

The first tea roller resembling the present machine was invented by S. C. Kinmond of the Assam Company. It consisted of two circular wooden discs, the lower stationary, the upper one moving with a concentric motion. The discs were cut in steps and canvas-covered, and confined in a box. The lower disc was pressed against the upper by weights running over pulleys. Such a machine was used to prepare the leaf for hand rolling.

William Jackson followed up Kinmond's machine and patented his cross-action roller in 1873, which attempted to copy the backward-and-forward motion used in hand rolling. The leaf was placed in a bottomless box which stood an inch or so above the rolling table and the top of the box was fitted with an adjustable cap for giving pressure. The box moved backwards and forwards and the table moved sideways. The first machine was used at Heeleakah in Assam.

Various types of boxes were tried about this time, in some of which the leaf moved in the annular space between the box and a moving cone whilst in others the rolling surfaces revolved in opposite directions.

Jackson soon abandoned the principles of his earlier rollers, the Cross-action, the Rajah and the Excelsior, and employed three double-crank suspensions in a vertical position, connecting the table and the box which, with the adjustable screw cap at the top, are the principles still holding in today's rollers. The first machine to embody these ideas was the Rapid in 1887 and all subsequent rollers are only mechanical improvements on this.

Planters and engineers frequently remark on the inefficiency of the tea roller. It certainly may be mechanically inefficient, but it distorts the leaf cells over a period of perhaps half an hour in such a manner that the oxidation process is well distributed over two to three hours and a desirable range of polyphenol condensation productions is obtained. Cell damage can certainly be done more quickly and efficiently, and the fermentation period shortened to obviate over-condensation of the polyphenols, but the mixture of products so formed is not as

acceptable as the mixture resulting from the leisurely rubbing of one leaf upon another in a tea roller.

Jackson's Rapid roller consisted of a square box and table, the former 32-in. or 24-in. The larger machine could deal with 300 lb. and the smaller with 200 lb. withered leaf. The modern machine today has a 36-in. diameter round brass box with a capacity of 350 to 450 lb. leaf, and the most recent rollers are made with a box about 47 in. in diameter taking up to 1,000 lb. leaf. Tea manufacture is a batch process and this puts a limit to the capacity of the individual roller, not only because the last part of a large batch may be over-fermented before it reaches the dryer but also because of undue heat development within a heavy charge of leaf.

A number of substances for the table have been tried, including wood, granite, cement, brass and stainless steel. Brass is in common use today for the box, the table and the battens, but the cap is often faced on the underside with wood.

Rollers may be single-action, in some of which the table moves and the box is stationary, whilst in others the box moves and the table is stationary. In double-action rollers both box and table move.

The pressure cap of a roller is raised or lowered by means of a chain over a pulley. Automatic caps have been invented which are raised and lowered at set intervals, and exert graded pressure as the roll proceeds. These caps have not been widely adopted because meticulous accuracy in the application of pressure is not needed.

There have been many kinds of battens used for the rolling table but none of these have had any peculiar virtue, except perhaps the batten with a sharp edge which raises the proportion of small pieces turned out, thereby increasing the Fannings and Broken grades. The subject of battens is mentioned again in the chapter on Ceylon where this aspect and cone rolling have received particular study.

There are six or seven makes of rollers at present available, but the teas turned out by them show no appreciable differences. All modern rollers do equally good work. A roller must be built to run smoothly, to last long, and to be economical with regard to new spare parts and its use of power.

During rolling the leaf heats up and in the second roll the

temperature may rise more than in the first, because of the pressure applied. The rise above air temperature may be as much as 20° F. depending on the degree of the wither, the stage of fermentation and the amount of pressure. To overcome the risk of loss of quality which accompanies high temperatures, the Marshall-Boustead brine-cooled roller was produced in Ceylon in 1931, in which the roller box was surrounded by a cool jacket and the temperature of the leaf kept at 70° F. In another type of machine, chilled air was blown into the bulk of the leaf in the roller which was thereby cooled to about 70° . Neither invention improved low-country teas in Ceylon, perhaps because these sell on strength, which increases up to a temperature of about 80° during fermentation.

As described in the section dealing with no-wither teas, unwithered or lightly withered leaf does not roll well and much leaf juice is expressed and lost through the crevices of the discharge door in the table. In 1912 W. F. Perman, in Assam, invented an expressor resembling a cotton press. The leaf is first lightly rolled to take out the springiness and is then expressed before rolling again. In treatment, about 10 lb. juice is expressed from 100 lb. leaf. This juice contains solids and the tea outturn is reduced by about 5 per cent, a loss which is not compensated for by any appreciable gain in the value of the tea made nor by the saving in fuel for the dryer.

About 1922 centrifugal machines, used for drying cotton, were employed for extracting moisture from rolled, underwithered tea leaf. The trial failed for the same reason that Perman's expressor failed.

During World War II, many factories in Java lost their withering accommodation and in order to roll the leaf satisfactorily when production started again in 1945, expressors were tried after a first light roll. In Nyasaland, expressors have also been recently used with a view to making unwithered leaf easy to roll. Great pressure is applied and losses up to 20 per cent of the made tea have been registered, due to the escape of the expressed juices. Apart from the fact that such treatment loses constituents of the leaf responsible for liquoring characteristics, the loss of weight of outturn puts the use of expressors out of court.

Many attempts have been made to damage the leaf in a

manner more efficient than that achieved by rollers. The use of chaff-cutters and tobacco-cutters has already been described. In 1925 T. A. Chalmers brought an entirely new idea to the problem with his Milling machine. It consisted of a single, transversely scored metal drum, and into the scores fitted the teeth of a metal comb which met the drum at right angles to the tangent. The once-rolled leaf was green sifted and the coarse leaf thrown on to the rapidly revolving drum, carried between drum and comb and distorted in the fraction of a second. The resultant teas showed leaf slightly crimped and gave coloury liquors which were a little harsh. The machine was perhaps ahead of its time and was not adopted.

About 1932 W. McKercher produced the crushing, tearing and curling machine, the C.T.C. consisting of two engraved metal rollers working like a mangle, one making 70 and the other 700 r.p.m. The coarse leaf from the make which has been rolled and green sifted twice is put through the machine and instantaneously distorted, an action which wrings out the leaf physically without loss of juice or rise in temperature, and also causes fuller oxidation than is obtained by rolling. If the machine is employed on the coarse leaf about ninety minutes after the start of normal rolling, a strong coloury liquor, albeit a little harsh, is obtained. The C.T.C. is widely used, especially with rains teas which have little natural quality, and if this treatment is applied as indicated the results are beneficial.

In 1933 the Dreadnought Equalizer, resembling a meat-mincing machine, was produced. The rolled leaf proceeds by way of an endless screw till it is forced through holes of adjustable sizes. The tea is smashed to Fannings and the liquors take on more colour and strength, with a little harshness.

In 1940 E. J. Nicholls produced the E. J. roller. This consists of two rollers working like a mangle, one roller being of solid metal and the other segmented and mounted on a rubber bush. As the partly rolled leaf passes between the rollers, the segmented one 'chatters' thereby shearing and distorting the leaf instantaneously. This machine is widely used.

The search continues for means of speeding up the cell-breaking process and of saving labour in the rolling room. But the time over which the cells are broken and the speed at which oxidation and subsequent condensation of the polyphenols

takes place cannot be much reduced if teas of the kind made at present are required.

Controlled experiment in Assam has shown that the best teas are made when the initial leaf charge in a 36-in. roller is about 280 lb. and two half-hour rolls are given. In the first roll most of the cell damage is done, whilst the second roll produces little further oxidation but wrings out the leaf and makes for more easy extraction in the five-minute infusion. The roller speed should be 50 to 70 r.p.m. Pressure should be applied in the second roll. The surface of the leaf bulk in the roller forms an ellipse, on the slant, the top of which moves round the box as rolling proceeds. When the cap is lowered, the top of this ellipse bumps against it at regular intervals and the pressure should never be so heavy that these bumps are extinguished. If such happens it means that the mass of the leaf is moving in a solid cake, the bottom of which is abraded by the table battens.

Green sifting cools and aerates the leaf, and removes fine pieces which have been sufficiently damaged thereby making for more efficient action in the second roll. The final sorting of the made tea is greatly simplified by green sifting, and true grades can only be made if the fines and the bulk are fired and sorted separately.

In green sifting bacterial cleanliness is very essential, both in the sifter itself, on the floor beneath, which should be tiled, and in the vessels used for carrying the leaf to the fermenting room.

The Fermentation of Tea

In Chapter V, the biochemical changes taking place during fermentation are described, and the effect of temperature and time on the resultant mixture of polyphenols which is extracted when tea is infused is indicated. The four factors in liquoring, quality, briskness, strength and colour, reach their optima at different times, and since they are each differently affected by temperature changes the best that can be achieved in fermentation is to take the mixture at its most acceptable make-up. The table below gives an idea of the relative times at which each liquoring quality is at its best at various temperatures. These times are not absolute, and the particular timings for each factory must be ascertained by experience.

	60° F. hours	70° F. hours	80° F. hours	90° F. hours
Briskness . . .		less than 2 hours		
Quality . . .	3½	2½	2	less than 2
Strength . . .	4¾	4½	4	3½
Colour (with milk). . .	4¼	3¾	3	less than 2

The best all-round liquor is made when the colour with milk is best. Apart from this, whatever adjustment in time is made because of temperature, quality deteriorates steadily between 60° and 100° whilst strength improves between 60° and 80° but then deteriorates. Even with reduced times, the harmful effects of high temperatures are not obviated. Overloaded rollers, too heavy pressure in rolling and too thick spreading on the fermenting space all raise temperatures and may lose quality.

Many substances have been used for the fermenting space including grass matting, wood, iron, galvanized sheet, glazed tiles, glass and cement. A cement floor is the coolest and even cement tables 3 in. thick conduct away the heat of fermentation well, so that leaf spread on such a surface may remain 3° F. cooler than when spread on thin aluminium sheets. The heating-up of the leaf on metal sheets is reduced if the underside of the sheet is painted a dull black. The benefit derived from metal sheets is due to the ease with which they can be kept bacterially clean, whilst cement is much more difficult in this respect.

Leaf should be spread 1 to 1½ in. thick, for then the temperature rise above that of the air is small. Thicker spreading does not reduce the diffusion of oxygen through leaf normally manufactured nor affect appreciably the time of fermentation, except in so far as the temperature is raised. With C.T.C. or tobacco-cut leaf, however, the close packing which takes place on spreading does hamper the passage of oxygen and thin spreading is essential on this account.

The relative humidity of the atmosphere has no effect on fermentation unless the air is so dry that the leaf surface blackens. Then fermentation is held up and a not undesirable brisk, greenish tea with piquancy results. The object in using humidifiers in a fermenting room is to lower the temperature, not primarily to raise the humidity.

Light has no effect on fermentation, although at the beginning

of the century planters put in blue, red and other coloured windows to the fermenting room with the idea that a certain coloured light improved the teas. Bright sunlight is harmful in that it raises the air temperature.

The Drying or Firing of Tea

Although liberties are often taken with the other processes of tea manufacture, both in detail and in the main, few experimenters have so far ignored the rules of good firing. It has been suggested that tea might be dried as spring grass is dried, in a fraction of a second at a temperature approaching $1,000^{\circ}$ F. in the gases of combustion. Tea is dried in a blast of hot air at about 200° F. but it can be dried in the actual gases of combustion. In the Dooars, the direct fumes from charcoal Producer gas have been successfully used, as in Upper Assam the products of combustion of an oil-burner were used. These gases were employed at about 200° however.

In the early days in Assam the iron pan heated from below was used for most of the drying of the rolled leaf, whilst the process was finished off on trays placed over a charcoal fire. The first drying machine was invented by McMeekin in Cachar in 1870 and resembled a chest-of-drawers holding four or five iron trays. The charcoal fumes from the fire below passed through the trays which were hand moved downwards. The fermented leaf was spread on the top tray and made its way to the bottom in about forty-five minutes.

The next advance was made by Dickinson in 1871 who generated hot air in a furnace outside the factory and drove it under the chest-of-drawers with a fan worked by animal power. In 1879 S. C. Davidson of Cachar introduced his Up-Draught Sirocco dryer. The furnace fumes and air going to the drying chamber passed through alternate sections, and the hot air rose by convection. The trays were moved by hand and temperatures up to 275° F. were used. Other similar machines were also invented about this time all with hand-worked trays.

The first dryer to use a fan as an integral part of the machine was Kinmond's. Air was drawn over a hot plate and into the chamber containing trays of leaf, hot air going direct to each tray, whilst part of the exhaust air was re-heated. Temperatures of 260° to 300° F. were employed and firing took eight minutes.

The first automatic dryer was that of Gibbs and Barry, consisting of a revolving cylinder, tilted and internally ribbed. The hot air blast was sent by fan into the lower part of the cylinder to meet the descending leaf.

In 1880 William Jackson produced his Venetian Dryer. The stove was a tubular one, the furnace gases heating the tubes through which the air was drawn by a fan placed on top of the drying chamber. The trays in the dryer were like the leaves of a venetian blind, and they were not removed but the leaf was emptied from one tray to the next below by a hand-operated handle. The Venetian (with a pressure fan and mechanically operated trays) is popular today, but the leaf is still hand-spread on the top tray.

Davidson replied to the Venetian with his Down-Draught Sirocco in which he used a fan and hand-operated trays, moved step by step. In 1885 Jackson invented the Victoria, a wholly mechanical dryer which included moving web trays of the Venetian type and except for the suction fan above the drying chamber, resembled present-day machines with its continuous feed and discharge. The Britannia followed and the Paragon in 1894, which remained a favourite for twenty years. This last dryer utilized both sides of a pair of trays, whereas in the earlier machines the trays only carried leaf on half their journeys.

In the early years of the century the suction fan was replaced by the pressure fan located between the stove and the chamber. The dryer then came to consist of three units, a stove for heating the air, a fan for gathering the hot air which is sent under pressure to the bottom of the drying chamber, and the chamber itself.

Davidson's Endless Chain Pressure dryer was produced in 1907 and the Double Tilting Tray in 1909. Jackson's Empire, his first pressure machine, was produced in 1910. The development of tea dryers has followed a logical course and recent improvements, of which there are many, are designed to economize in fuel, to make the most of the air blast, to ensure even drying and to give speedy control. All modern dryers do the same work and tasters are unable to distinguish between teas fired in different machines.

With the light wither employed in Assam, tea is most economically fired in two operations, the first taking the leaf to

a state of surface crispness, about 15 per cent moisture, and the second reducing the moisture to 1 to 3 per cent. During the first fire the leaf is a 'wet' body which takes on the temperature of the wet bulb of the air blast. The air enters the first-fire machine with dry and wet bulbs about $200^{\circ}/100^{\circ}$ F. respectively, and it should leave the dryer with a dry bulb reading of 120° to 130° . The wet bulb at the exhaust will still be at 100° and the leaf on leaving the first dryer will not be much hotter than this temperature, for it has only just ceased to be a 'wet' body. One great benefit of double firing arises from this fact, for if necessary the first-fire initial temperature may be raised to 220° or even 240° without harm, since the leaf bulk itself gets not much hotter than 100° .

In the second fire the leaf becomes a hygroscopic body which tends to take on the temperature of the dry bulb. It is during this fire that the leaf gets its keeping qualities by virtue of the fact that its temperature rises. In this operation, the air blast should enter the dryer at 180° , no higher. The time of the first fire should be twenty to twenty-five minutes and of the second ten to fifteen minutes.

Dial thermometers at the inlets of all dryers are essential, as they are at the exhausts of all first-fire machines. In the first fire, the firing time and the exhaust temperature are fixed, but the thickness of the spread and the inlet temperature may be varied. Thus allowances can be made for under-withered or over-withered leaf, so that leaf of the same dryness can be fed to the second dryer at a steady rate to be fired at 180° within a fixed time.

If leaf in Assam is withered to 75 per cent, it goes to the rollers with about 66 per cent moisture, and at this same figure to the dryer. After the first fire the moisture is reduced to about 15 per cent and on discharge from the second dryer to 1 to 3 per cent. During sorting the moisture may rise to 6 per cent. When the grade is taken from the bin for packing it is finally fired at about 160° for ten minutes, which takes the moisture back to about 3 per cent. The grade is then bulked in a warm, dry atmosphere and packed, by which time the moisture will have risen to 4 or 5 per cent. Between leaving the factory in Assam and sampling in London before the sale, the packed tea may show a moisture increase of 0.3 per cent.

The fuel used for dryers may be coal, wood or oil. Electricity has been tried but it is too expensive at present since it takes 0·8 to 1 unit to fire 1 lb. tea made from well-withered leaf. It is difficult to give comparative figures for the various fuels owing to the variability in the degree of wither and the thoroughness of the firing. In Assam it takes 0·35 to 1 lb. coal to fire 1 lb. tea. In Ceylon it takes 9 lb. liquid fuel to fire 35 to 50 lb. tea. In South India it takes $1\frac{1}{2}$ to 2 lb. wood to fire 1 lb. tea. In the last case, it may be stated that the dryness of the wood, the size of the billets and the efficiency of the stoking all greatly affect the rate of consumption.

Since 1937 many factories in Assam and other tea countries have used steam in suitable radiators to heat the air for the dryer. The steam is generated to provide power for driving the factory engines and then used for drying. The system has been scientifically worked out and as a result there is a saving in the overall use of fuel, an improvement in the evenness of the drying and much greater cleanliness in the factory than when coal or wood are employed. With steam heating, the stove of the dryer is no longer needed.

The Sorting of Tea

In the early days in Assam, tea was sifted by hand in round bamboo sieves or *soops* with meshes of 4, 6, 7, 9, 10, 12 and 16 holes per inch. By 1870 brass mesh was in use. The terms used to define the grades were Pekoe, Souchong, Congou and Bohea, denoting a decreasing order of fineness. The leaf passing through No. 9 mesh was Pekoe, through No. 6 or 7 was Souchong, whilst No. 4 gave Congou. The leaf was hand-rolled off course and the fine broken grades made nowadays were not produced. A man could sift 80 lb. tea a day with the help of boys to pick out the stalk and red leaf. Threequarters of the outturn was leaf grades and the rest broken grades, fannings and dust. A modern sifting machine can deal with 1,000 lb. tea per hour, it may be noted.

As soon as engine power was introduced into Assam, Jackson invented his first tea sifter in 1875, and a year or so later Reid's breaker was produced. Jackson also invented a breaker and both types of machine are still in use. In order to avoid the greying of the leaf brought about by these breakers, the Savage

cutter was invented, consisting of two rollers, honey-combed with small square cells. Many other cutters and breakers are now available.

Stalk separators and extractors have been invented, notably the Bateman produced in 1920 which takes advantage of the natural separation of stalk and leaf occurring below the Savage cutter. A few years later the Myddleton stalk extractor came on the market, consisting of aluminium sheets dotted with perforated nipples. The stalk slides between the nipples and the leaf hops through the perforations.

For cleaning the grades of dust and light stuff, the McDonald Deflector, resembling a chaff winnower was invented in 1907. In Java a much more elaborate wind tunnel has been developed, which separates most grades.

To revert now to sifters, these may be rotary, reciprocating or may work with a flat circular movement. The first assortment of tea is done in the green, fermented-leaf stage and the first and second fines after firing go to make the Broken Orange Pekoe, the B.O.P. Fannings and the O.P. grades. The coarse leaf, which is first broken or cut, goes to produce the Broken Pekoe, P. Fannings, Pekoe and Souchong grades. It usually happens that the two widely different grades, the B.O.P. and B.P. pass the same mesh in sifting, through 8-mesh and over 10. There is hence no question of putting all the outturn on a multi-sieved machine and taking various grades from various delivery chutes. It follows that a suitable way of sorting is to have three or four single-tray machines each of a different mesh and to use these as required. The multi-sieved machines, and there are many, certainly do the job well, but for straightforwardness and control the simple single-tray sifters are preferable.

The sorting room atmosphere is often laden with fluff and dust, and most factories have the individual machines hooded so that the dust can be ducted away and the air kept clean. If the relative humidity of the air in the sorting room is about 65 per cent, i.e. the wet bulb depression is 7° to 8° F. the tea will neither lose nor gain moisture, but this aspect is given little attention in tea factories although it is a fact worth keeping in mind.

The tea waste or fluff which is swept from the factory floors, together with stalk and coarse leaf is sold in sacks to chemical

firms, who extract the caffeine for medical purposes and for use in the make-up of certain soft drinks. The caffeine content of tea waste is 2 to 3 per cent and such waste may constitute 0.2 per cent of the annual outturn.

When sufficient tea has accumulated in the bins to make an invoice, each grade is taken out in turn and finally fired. It is then bulked on a tarpaulin by the simple process of tipping successive chests of the grade in a circle and then shovelling it into the centre. The bulked grade is then put into chests which are mechanically shaken.

In the early days, $\frac{1}{2}$ -in. machine-cut planks were imported from Rangoon for boxes and a chest weighed 33 lb. In 1900 steel chests were tried but were not a success. Then planks or shooks were imported from Japan and locally made shooks of simul wood were also used. At the turn of the century three-ply wood was introduced from Canada and Scandinavia, $\frac{3}{16}$ in. thick and a chest weighing 18 lb. was then possible, since reduced to 14 lb. Now three-ply is made in India.

The linings of tea chests have changed in the past few years. At one time lead foil was the rule, but Food Regulations following on agitation from certain consumer countries about 1930 put these out of court. As an extra precaution, the use of lead in tea machinery has also been abandoned on account of possible contamination. The common chest lining now is aluminium foil with white parchment paper between the metal and the tea. Many substances, including plastics and unvulcanized rubber products have been tried as linings.

General Conclusions

At the end of this description of tea culture in North-East India, it is fitting to summarize the conclusions of many observers regarding the relationship between the culture and the manufacture of the leaf and the final product.

1. The quality of the tea made depends primarily on the type of bush grown and this can affect the value of the outturn by pence per pound. To make fine tea, fine leaf must be plucked. Unless quality is inherent in the leaf it cannot be developed in manufacture, although it can be destroyed by incorrect manufacture.

2. To make the best of the leaf plucked, factory machinery,

equipment and space should be adequate and sufficient to cope with the crop on a big day in sixteen hours, a double shift. The whole factory, especially the rolling and fermenting spaces, must be kept bacterially clean as far as practicable. The rolling and fermenting rooms must be cool, with temperatures not above 80°F. at any time and lower if possible when quality is present. Orthodox methods of procedure must be followed if an orthodox tea is required and any departure from normal times, temperatures and degree of wither, will produce a tea more or less different from normal. The constant close control of every operation and the keeping of detailed records are, in practice, essential to making the best of the leaf.

CHAPTER XII

TEA IN CEYLON AND SOUTH INDIA

The tea industry in Ceylon—Soil management in Ceylon—Planting, pruning and plucking—Pests and diseases—Manufacture in Ceylon—The tea industry in South India—Methods in South India.

CEYLON is a geographical extension of South India and conditions with regard to tea planting are similar in the two areas. Ceylon is a pear-shaped island measuring about 300 miles from north to south and at its widest about 150 miles. Kandy is the ancient capital and Colombo is the port and business centre. Two-thirds of the island receives most of its rain from only one monsoon, but the rest is liberally served by two and abounds in luxuriant vegetation. In this latter area, rubber and most of the tea and coconuts are planted. Rice is mainly grown in the irrigated dry zone. The tea areas lie about 7° N. of the equator.

The tea planting country in South India is stretched out along the Western Ghats and the Cardamom Hills for a distance of about 300 miles, from Coorg, 13° N. to South Travancore, 9° N. of the equator. Except for the Nilgiris, most of the tea areas are served mainly by the south-west monsoon. Coffee, rubber, coconuts, cardamoms, pepper, cashew nuts and other cash crops are grown in this area. As in Ceylon, a distance of ten miles beyond the limits of the south-west monsoon area can witness a change from tropical forest to semi-arid vegetation consisting of thorny, small-leaved plants and the cactus.

The Tea Industry in Ceylon

The Ceylon tea districts form a compact area in the central core of mountains and in the foothills to the west and south-

west. The railway from Colombo to Badulla passes through much of the tea land in its journey of 180 miles. For the first fifty miles or so the line runs through rice fields broken by hillocks of red soil. Then the line begins to rise, the planting district is entered and cacao, rubber, tea, cardamoms, coconuts and other crops are grown. Kandy, about seventy miles, is situated at 1,700 ft. and nearby are the famous botanical gardens of Peradeniya. Above Kandy, tea estates become more frequent and the route continues by way of Nawalapitiya at 4,000 ft., the optimum height for precipitation, where the hills face the south-west monsoon and 270 in. average rainfall is registered. Then comes the Dikoya district with Hatton the centre of the tea country, formerly an important coffee area. Much of the tea is planted on old coffee land, partially exhausted and often eroded. Some of the tea factories were relics of the coffee days, situated at the bottom of the valley to utilize water-power, but many have been rebuilt higher up the slope where day temperatures are lower and more suited to tea manufacture.

The Dimbula tea district adjoins Dikoya and is said to be the best in Ceylon. The Tea Research Institute of Ceylon is at St. Coombs, in this area. From Nanu Oya a narrow gauge line runs to Nuwara Eliya, 6,188 ft., and on to Kandapola and Ragalla, districts containing fine tea estates. At present no jungle area above 5,000 ft. is granted by Government for tea land, but much of the area already planted is above this altitude, some as high as 7,000 ft.

Continuing along the main line from Nanu Oya, the highest point reached is at Pattipola 6,225 ft., in which location the patanas or grassy downs of the Uva district are entered. The line descends to Haputale and Bandarawala, both over 4,000 ft., and then on to Badulla, 148 miles by road from Colombo, standing at a little over 2,000 ft. Uva is served mainly by the north-east monsoon, since the south-west largely spends itself on the other face of the mountain massif. The rainfall at Nuwara Eliya, which escapes the full force of the south-west monsoon but is generously treated by both, averages 93 in. whilst Badulla receives 73 in., most of which is recorded between October and April, from the north-east.

The low-grown tea of Ceylon is planted on the south-west

and western side of the mountains, the chief district being the Kelani Valley.

Of the total area of 555,000 acres under tea, 120,000 are above 4,000 ft. and reckoned high-grown, 220,000 are between 2,000 and 4,000 ft. and are medium-grown, whilst 140,000 are below 2,000 ft. and are low-grown. About 75,000 acres are unclassified in the above manner. There are 2,400 estates, average over 200 acres each, and 78,000 small holdings, average less than 1 acre each.

In 1875 coffee was the chief crop planted in Ceylon. In the year 1869 the coffee plant was attacked by a leaf disease, *Hemeleia vestatrix* the danger of which was only realized after it had got out of control, with the result within a few years the coffee area of 300,000 acres ceased to exist. Following this failure, cinchona was planted but, owing to over-production and competition from Java, this crop soon ceased to be a paying one.

Tea was first planted in the 'sixties and by 1875 about 1,000 acres had been put out. Such was the success of the new crop that by 1895 over 300,000 acres were planted and in 1925 the area was considered to be about 450,000 acres. When the International Tea Regulation scheme was worked out in 1933, it was disclosed that the area of estates of 10 acres or more in extent made up 492,000 acres and small holdings, of under 10 acres, no less than 64,000, a grand total of 556,000 acres.

Labour for the tea estates is recruited from South India.

The tea industry is highly organized in Ceylon in a manner similar to that in North-East India. The commodity is sold either by auction in Colombo or shipped thence to London for auction. The average price realized by Ceylon teas is higher than that shown by Indian teas. Prices vary with the season and the elevation of the estate, the high-grown areas making the best average price, followed usually by the medium, then the low-grown teas.

The distribution of tea exports from Ceylon has altered since the war and some of the markets previously served by Indonesia, notably those in Australia, the United States and Egypt are, for the time being at any rate, now largely supplied by Ceylon. The following table indicates this change.

DISTRIBUTION OF TEA EXPORTS FROM CEYLON, 1938 AND 1953

<i>Country</i>	1938 <i>million lb.</i>	1953 <i>million lb.</i>
United Kingdom .	166	118
Canada .	8	18
Australia .	13	52
New Zealand .	9	13
South Africa .	11	23
United States .	13	34
Egypt .	3	23
Iraq .	1	21
Others .	22	34
Total	236 million lb.	336 million lb.

The scientific work on tea was previously conducted by the Government Department of Agriculture at Peradeniya. In 1925, a separate organization known as the Tea Research Institute of Ceylon was formed to carry out research connected with tea. In 1928 St. Coombs estate with a factory and about 300 acres of tea was purchased and laboratories established there. The findings of the Institute have had a marked effect on every aspect of procedure both in field and factory not only in Ceylon but other tea countries, whilst from the commercial point of view St. Coombs estate, managed scientifically, has produced yields much above the district average and teas of outstanding quality.

Soil Management in Ceylon

Soon after the Tea Research Institute was established, experiments were laid down to examine the response of tea, normally pruned and plucked, to different levels of application of nitrogen, phosphoric acid and potash. In the high-grown areas of Ceylon the tea is pruned on a three- or four-year cycle, and the pruning would be considered medium or medium-heavy in Assam. This point will be reverted to later.

In the year of pruning, the bush gives a poor response to nitrogen, phosphates or potash, since recovery from pruning is dependent on food stored within the plant. In the second and third years the response is marked, each 1 lb. nitrogen applied increasing the crop by 4 or 5 lb. tea, whether it is given as

sulphate of ammonia, blood meal or oil-cake. The increase from doses of 40, 60 and 80 lb. nitrogen is in proportion to the size of the dose.

With regard to the effect of phosphatic fertilizers, it is found that above about 30 lb. phosphoric acid per acre no further response is obtained. For the first twelve years of the experiment, no results were obtained from potash, but then areas not receiving the mineral began to show crop decline although as with phosphates, 20 to 30 lb. potash per acre are sufficient.

All three nutrients appear to act independently, so that the effect of two equals the sum of the effects of either alone. Nitrogenous and phosphatic manures have no appreciable effect on the quality of the tea, but with potash quality improves.

As a result of these findings a mixture of sulphate of ammonia, ground rock phosphate and potash, called 'T.R.I. 500', has been devised and it is suggested that for each 1,000 lb. tea cropped, 625 lb. of the mixture be added to the soil. The amounts of the three nutrients taken from the soil by an annual crop of 1,000 lb. tea, plus the pruning wood carried away every third year, average about $N/P/K=64/16/35$ lb. per acre per annum. The advised dose of mixture puts back $N/P/K=80/39/47$ lb. per acre. The mixture also supplies small amounts of calcium and magnesium, some sulphur, iron, manganese and copper, all of which are just as essential to tea growth as are N, P and K although they are seldom short in the soil. Nevertheless, steady cropping may sooner or later lead to a deficiency in these less considered elements.

This generous treatment of tea in Ceylon may be contrasted with that in Assam where experiment has shown that crops of 1,250 lb. tea per acre may be maintained with an annual dose of 80 lb. nitrogen only, whilst such crops can also be harvested with no other assistance than that given by a canopy of leguminous shade trees.

In Ceylon it has been shown that nitrogen given as fertilizer not only increases the crop but also the nitrogen content of the leaf. Phosphates and potash increase the crop to a certain degree, after which the plant acts as a luxury feeder, assimilating and storing these minerals.

In Ceylon the soil is scraped clean of weeds and kept clean

in a way never seen in North-East India or for that matter either in South India. The soil is envelope forked, whereby a fork is driven in about 1 foot, moved backwards then forwards and any organic matter or leaves from prunings pushed into the envelope with the foot. There is no turning of the soil. Such a round of treatment leaves a series of small ridges which cause rain to soak in and reduce erosion. The tea roots are able to penetrate soil so loosened and the beneficial effects of good cultivation are apparent for up to eight years. It is common to fork annually before adding fertilizer but the forking can be overdone, whilst the scraping of weeds may even encourage some of the quick-growing varieties.

The difference between Ceylon and Assam field methods is very great. In Assam the land is never deep cultivated and seldom light hoed, in fact procedure there is such that the soil is reverting to the jungle state. This is possible because of the cover given by the tea which gets a light annual or biennial prune, and because of the heavy canopy of leguminous shade. Natural conditions are all in favour of Assam, and these include a cool dry season when plant growth slows up or ceases, a flat lie of land and foolproof soils.

Before leaving the subject of soil management, a further difference between findings in Assam and in Ceylon must be recorded. In Assam, prunings and other organic matter are left on the surface of the soil and no benefit arises from burying them. Yet in Ceylon, the leaf from prunings and other organic matter is buried because if left on the surface in alternate rain and sunshine nitrogen is said to be lost to the soil.

Planting, Pruning and Plucking

The tea stand in Ceylon is of very mixed origin and large-leaved bushes of the Shan and Burma types can be seen growing next to small-leaved China plants, whilst every type of hybrid abounds. Much of the seed probably came from Java, to which country the plants were originally brought from China, and was imported after the failure of coffee in 1875.

Observations in Ceylon have shown that in a uniform area of tea comprising 1,000 bushes, individual bush yields may show a tenfold range of variation. In some cases the range has been even more extended than this.

The need for selection of high-yielding, high-quality bushes is apparent and since 1937 vegetative propagation has been under study. Clones have been developed which give twice to three times the average crop, produce teas of above average quality and show some resistance to disease. The technique of propagation by leaf cuttings has been developed and defined. A well-grown selected tea bush can yield 1,000 cuttings in a year and the gradual replacement of present areas of tea by selected clones is under consideration.

A scheme of procedure for replanting with cuttings has been worked out. The uprooted area is contour trenched and planted with Guatemala grass, *Tripsocum laxum* which is frequently lopped and eventually cut and put into the trenches. Two years after the original uprooting the nursery tea cuttings are planted and the new stand is reckoned to be in bearing within two years from planting, which is earlier than had nursery stumps, grown from seed, been used.

As indicated in the previous section, the pruning in Ceylon in the high-grown areas is on a three- or four-year cycle, but the cut is heavy and not at all the same as with the annual or biennial top-prune in Assam or even the prune in Darjeeling where a four-year cycle is practised. The possible advantages of lighter pruning are however realized and such is advocated by the Tea Research Institute, where experiments have shown its beneficial effects.

In the areas up to 3,000 ft. where the pruning cycle may range from one and a half to two years, a serious percentage of deaths frequently occurs after cutting, and these have been shown to be due to a shortage of starch reserves in the roots. Experiment showed that the losses varied with the cleanness of the pruning and that when ample foliage was left on the bush the chance of recovery increased. Accordingly, 'rim-lung' pruning whereby several branches with their leaves are left unpruned, or 'cut-across' pruning whereby foliage is left below the cut, are employed with beneficial results.

After the bush is pruned in Ceylon it is allowed to grow freely till the new shoots show red wood at the base. They are then broken back to leave a flat surface about 4 in. above the pruning level. This is called 'tipping' and is almost as severe as top-pruning in Assam. In this way up to 9 in. of new growth may

be removed from the centre of the bush and less at the sides. A second 'tipping', less severe than the first may be done, after which plucking begins and this is above a single leaf.

Experiment has shown that plucking to the *janam*, as in Assam, does not pay in Ceylon, and that the total weight of the crop taken plus the foliage and pruned wood at the end of the pruning cycle is only about two-thirds with plucking to the *janam* compared with the total weight when plucking is above a leaf. However, the actual crop of leaf is about 50 per cent higher with *janam* plucking than with the lighter style of cropping. It would be interesting to see how close plucking on a 6 or 8-in. initial run after top-pruning in the Assam style would compare with the Ceylon procedure of rather heavy pruning, severe 'tipping' and light plucking.

Pests and Diseases

The pests and diseases of tea have always been closely studied in Ceylon for the failure of the coffee plantations in 1875 has been kept in mind. Most of the fungus diseases known in India occur in Ceylon although not always to the same degree of seriousness in both countries. A similar state of affairs happens with regard to pests. Mention however will only be made of Blister blight, *Exobasidium vexans* recognized in Assam as long ago as 1858 but not seen in South India or Ceylon till recently. The fungus is an obligate parasite and lives only on live tissue, attacking the young leaves of the tea plant. The fungus does not immediately kill the part of the plant it enters although death follows in due course, but not until the fungus has completed its life cycle and reproduced its kind. With pruned tea, especially heavy-pruned, the loss of the first young flush, produced at the expense of reserve foodstuffs, is a serious handicap which may well cause the death of the bush. Dull, cool, weather encourages the fungus, whilst bright sun discourages it.

In 1946 Blister blight appeared in Central Travancore, South India, and soon spread to Ceylon, then to Sumatra, Malaya and Java. It is possible that ungerminated spores were air-borne from one country to another. Pruning times were modified to reduce the effects of the disease, and closer plucking during attacks was employed to remove the leaf before it was

attacked. A technique of low volume knapsack spraying with a copper fungicide was worked out for dealing with about 250,000 acres of tea in Ceylon every ten days throughout the monsoon.

It was inevitable with so much spraying that the copper content of the made tea should increase. Copper occurs naturally within the tea leaf, and the enzyme responsible for fermentation is a copper-protein compound. In Ceylon the natural copper content of the tea is about 25 parts per million parts dry leaf and after rolling in a brass roller the figure increases to about 35 p.p.m. Tea made from sprayed bushes may contain up to 150 p.p.m. and this last figure has been agreed to as acceptable by the Food Standards Committee in Great Britain. In the actual infusion of such tea the copper content is well below $\frac{1}{2}$ p.p.m. of liquid, as against 2 p.p.m. allowed normally for beverages other than wines, beer and cider.

Tea Manufacture in Ceylon

Ceylon teas are noted for their quality and flavour which result from a number of factors, two of which are the fine leaf plucked and the meticulous care taken in manufacture. The type of bush grown no doubt is a great influence, whilst low temperatures are a help in conserving quality in the up-country factories.

Manufacture in conjunction with vegetative propagation has received close study for many years. Generally speaking, the small leaf varieties give quality but poor yield, although the relationship between quality and leaf is not closely defined. The characteristics of the tea made from the leaf of the mother bush are transmitted to that of the progeny grown from cuttings. Selected low-country bushes give teas with strength and colour, but not the quality of up-country tea. Long experience in the manufacture of leaf from individual bushes has failed to show a close relationship between the colour of the infused leaf and the liquoring properties of the tea. The general conclusion is reached that quality is made in the field and that any improvement in the tea by better methods of processing bears no comparison with what can be achieved by taking the right kind of leaf. The same conclusion has been reached in Assam.

Procedure in Ceylon varies according to the altitude of the

estate. In the high-grown areas the wither is a full one, to about 60 per cent, i.e. 100 lb. leaf to 60 lb. In the lower areas a lighter wither is given. The rolls may range from three to six with a norm of four and more rolling is given in the high-grown than in the low country. The rollers make 40 to 50 r.p.m. as against 50 to 70 in Assam. Firing is carried out in a single operation.

The withering lofts are controlled with great care, and attention to temperature and hygrometric difference of the air flow, the latter being kept at 5° to 7° F. The high degree of development of the Ceylon loft certainly plays a part in developing the quality in the leaf.

Drum withering has recently been the subject of experiment both in commercial factories and at the Tea Research Institute. The fact that a time lapse up to eighteen hours after plucking is essential for the chemical wither to develop, and that drum temperatures even as low as 100° F. for two hours produce dull teas whilst temperatures of 130° kill the leaf in twenty minutes, complicate the scheme. Thus the leaf must be held over, preferably before treatment in the drum, and this delay and extra handling may well put the process out of court, even if it produced as good teas as loft-withered leaf.

The study of leaf rolling and bruising has been gone into in detail in Ceylon as has the ultimate result of green sifting. Every reasonable form of batten has been tried out, the effect of pressure caps has been considered and cone rolling developed. With regard to the last, cones, pillars, studs and pyramids of many dimensions have been used. The Clivemeare roller, which consists of two metal cylinders working like a mangle, has been under exhaustive experiment. This machine crushes the partially rolled leaf instantaneously and is in effect a more vigorous agent of distortion than the C.T.C. machine. From such crushed leaf the tea can be pelleted and about 1940 this system of production and presentation was tried out.

Tobacco-cut teas have been made using fresh leaf and withered leaf, both before and after rolling, fine cuts and coarse cuts have been tried and many other modifications made, but the teas thus produced have not the true Ceylon character and are in all respects inferior to teas made by the traditional methods.

Cold rollers, with brine-cooled jackets or cooled by streams of chilled air, were under experiment in 1935 in the low country. They did not succeed possibly because when strength is being developed in tea a temperature of about 80° F. in fermentation is preferable to a lower one.

Experiments in drying involving fundamental principles have also been undertaken in Ceylon. The use of steam heating for dryers was used as long ago as 1880. At the Tea Research Station the products of combustion of an oil-burner have been used to dry tea, but in both cases the temperature of the air or gas has been about the normal 200° F. Many years ago experiments were made in drying tea with a blast of cold air at a temperature of 65° F. A strong, flavoury product was obtained but it would not keep.

All the above departures from normal when they involved some fundamental change in leaf treatment have only been made on a limited scale, and most factories have very rightly kept to orthodox procedure. Although visiting industrial experts and missions usually suggest the desirability of such experiments, the products of unorthodox manufacture have never found favour with the trade. This is to be expected. The present system admittedly involves lengthy processes, but it has been developed over many decades through trial and error, and it produces a commodity to suit the trade. Modifications in procedure alter biochemical reactions taking place during manufacture, and a different kind of tea must result from such changes. Lower prices at the auctions show that such changes do not pay.

These conclusions, reached by scientists working in Ceylon, agree with those of scientists working in Assam. Unorthodox manufacture gives a different tea from that made by normal processes.

The Tea Industry in South India

Although the tea industry in South India is a modern one this area was early the scene of experiment. When in 1834 Lord William Bentinck sent a commission to China to obtain seed, many plants were sent to the Nilgiris where they were planted chiefly at the experimental farm at Kaity. In 1839 these plants were said to be growing luxuriantly whilst success

was also reported in the Wynaad. Not till 1853 was the production of tea taken up commercially although little progress was made till much later, and the industry did not get under weigh till about 1893.

Many plantation crops have been tried in South India including coffee, rubber, cardamoms, pepper, cinchona and sisal, but tea, coffee and rubber are the chief ones. Other cash crops include the coconut, cashew nut and lemon grass oil. The making of coir products and mats is a major industry on the coast, for the backwaters are particularly suited to the retting of coconut husk. Spices are grown, whilst on the dry side of the hills in Tinevelly is a senna plantation. To add to the wealth of this area, the beach-sands of Travancore produce the bulk of the world's supply of monozite, washed down from the mountains. The sands yield thorium, used in gas mantles, mesathorium, a substitute for radium, ilmenite, used in white paints, and other rare and valuable metals some of special significance in atomic fission.

The registered acreages of the main plantation crops in South India were roughly as follows in 1953:

	<i>Acres</i>
Coffee . . .	250,000
Rubber . . .	177,500
Tea . . .	173,000
Cardamoms . . .	35,000
Cinchona . . .	8,000
Pepper . . .	2,700
Total	<u>646,700 acres</u>

The development of the tea industry has been along similar lines to those followed in North-East India and Ceylon, with Agency Houses on the Malabar Coast at Cannanore, Calicut, Cochin, Aleppy and Quilon. In 1893 the United Planters Association of Southern India, the Upasi, was formed and this co-ordinated the activities of planting concerns dealing not only with tea but with other crops.

In 1926 a Tea Scientific Department was set up by the Upasi at Devarshola in the Nilgiri-Wynaad area, to the north of and below the Nilgiri plateau. In 1948 at Cochin, the deep-water

harbour on the Malabar coast, a tea market with auctions was opened, whereas previously South Indian teas were usually auctioned in London or Colombo. In the first three years of the market, the total sales were 5 to 7 million lb. annually, but in 1951 the auctions dealt with 20 million lb. rising to 25 the next year and to 33 million lb. in 1953. An idea of the importance of Cochin is given by the fact that, in this last year, the Chittagong auctions dealt with 22 million lb. those in Calcutta with 256 million lb. and in Colombo with 258 million lb.

The total area planted to tea in South India in 1953 amounted to about 173,000 acres and the production to 121 million lb. tea. About a fifth of the total acreage and outturn of tea in India is in the South. The average outturn is 700 lb. per acre against 800 lb. in North-East India. The distribution of acreage according to districts, running from north to south, is as shown below:

TEA DISTRICTS IN SOUTH INDIA

		<i>Acres</i>
Mysore and Coorg	.	4,248
Madras	{ Wynaad	14,269
	{ Nilgiri-Wynaad	14,069
	{ Nilgiris	28,317
	{ Anamalais	27,026
Travancore-Cochin	{ Kanan Devans (High Range)	36,081
	{ Central Travancore	37,309
	{ South Travancore	11,439
Total		<u>172,758 acres</u>

The tea in the Wynaad is put out on the lower slopes of the Western Ghats up to 2,000 or 3,000 ft. altitude, whilst the Nilgiri-Wynaad estates are on the higher slopes rising to the Nilgiri plateau. This plateau reaches its highest altitude in Dodabetta, 8,760 ft. and much of the Nilgiri tea is planted at 5,000 ft. and above. The plateau falls precipitously to the plains of the Palghat Gap, a pass about forty miles wide which separates the Nilgiris and what is in effect the continuation of the Western Ghats which south of the Gap goes by the name of the Cardamom Hills. In the plains of the Gap much cotton is grown and Coimbatore is an important spinning centre. South

of the Gap the Cardamom Hills rise to form a T-shaped range, with the Anamalais district occupying the Western or wet arm of the letter T, whilst the opposite arm comprises the Palni Hills, largely grasslands on the dry side of the range. The Cardamoms rise rapidly to the Anaimudi Peak 8,841 ft. and in its vicinity is the High Range area or Kanan Devans, extending from the wet western slopes to the dry eastern ones. The High Range, average about 5,000 ft., stands above the Anamalais which lie at 3,000 ft. Further south, in from Alleppy, is the district of Central Travancore, including the Mundakayams, and still further south, in from Quilon, is the district of South Travancore where much of the tea is planted below 1,000 ft. altitude.

Thus the tea districts are located at elevations ranging from sea-level to over 5,000 ft. and perhaps the highest tea in the world is planted in part of the Kanan Devans at 8,000 ft. The tea fields are on the slopes of the mountains or plateaux, subjected to one or both of the north-east and south-west monsoons, and the annual rainfall ranges from 40 to 300 in.

The disadvantages of hill planting are apparent of course and the continuous sheets of tea usual in Assam are lacking. Nevertheless, some areas are very fine, whilst the Anamalais, occupying a basin in the Cardamom Hills, is a district which compares favourably with the best. Many of the factories are as good as those found anywhere in the tea industry, not only with regard to layout and equipment but also in organization and control.

There are several large hydro-electric stations in South India serving a grid, and many of the factories run on electric power. In some factories extensive attempts have been made to mechanize work by means of electrical equipment, moving belts and press-button control but, with a batch process such as is followed in tea manufacture, there has been little saving of labour.

Methods in South India

Although the earlier tea areas planted in South India were sometimes put out with bushes of the China strain, the more recent plantings have been with seed from Assam, mostly of the Burma type. Ceylon field and factory procedure is followed in the main, although there are many deviations. Thus the

periodic pruning is not as severe as in Ceylon and in the high-grown areas the cycle may be as long as seven years. Plucking is closer and often to the fish leaf in the rush period. Weeds are tolerated to an extent seldom seen in Ceylon whilst deep cultivation is not regarded as essential.

Valuable results from manurial experiments laid down at the Research Station in 1940 are now available. These show the beneficial effects of nitrogenous manures, but practically no response from phosphatic fertilizers. However, the importance of potash has been demonstrated in times of drought and if nitrogenous manures are given without potash the decline of the stand in such cases is hastened.

Mosquito blight, *Helopeltis* which was for many years a serious pest in Central and South Travancore, was brought under control in 1946 with D.D.T. applied as a dust. Blister blight, *Exobasidium vexans* appeared in Central Travancore in 1946 and in 1948 was reckoned to be taking a toll of 20 to 25 per cent of the crop in affected areas. This disease has also been controlled, partly by dusting with copper fungicides and partly by modifications in pruning times and closeness of plucking during the periods of likely attack.

The potentialities in South India for many cash crops and plantation crops are great. There are extensive areas of land suitable for tea plantations.

CHAPTER XIII

TEA IN INDONESIA AND FURTHER INDIA

*Tea in Indonesia—Methods in Indonesia—Tea in Malaya
—Indo-China—The Shan States—Papua, New Guinea and
Queensland.*

IN this chapter some information is given on tea growing in Java and Sumatra, in Malaya, Siam, Burma, Indo-China, in New Guinea and Queensland. One reason for treating these areas together is that they comprise a continuous geographical unit largely composed of what has become loosely to be termed South-East Asia.

The countries mentioned cover the widest possible range of conditions and procedure. Thus, Burma, Siam and Indo-China are monsoon countries, whilst Malaya, Indonesia, New Guinea and North Queensland are tropical lands outside the range of the monsoon.

In the Shan States of Burma and Siam pickled tea is made in a primitive manner, whilst in Indo-China the ancient Chinese hand method of preparation is followed. In a few European-owned estates recently developed in the last area modern methods of culture and manufacture are practised, as they are in Java, Sumatra and Malaya.

Java witnessed the absolute beginnings of the European connexion with tea planting, whilst in New Guinea and Queensland the tea venture is at present only just under consideration. Finally, another distinction, albeit an academic one, cutting across the comprehensive area now under review is Wallace's line, depending on differences of flora and fauna, which runs between the East Indies and New Guinea and is considered to divide Asia from Australia.

Tea in Indonesia

The development of the East Indies began with the Dutch who settled in Djakarta early in the seventeenth century and renamed it Batavia. With the years, they gradually formed an empire which included Java, Sumatra, most of Borneo, Celebes,

part of New Guinea and many other islands collectively designated as the Netherlands East Indies. Java was the most highly developed area, with conditions and amenities better perhaps than those of any other country in tropical Asia. Many estate products became of great commercial importance including rubber, sugar, coffee, tea, tobacco and cinchona, the last of which Java possessed a world monopoly, supplying over 90 per cent of the commodity marketed. During the war, the islands were occupied by the Japanese in 1942 and plantation work then largely ceased. After the war, all was confusion and lawlessness, but the islands gained their independence and formed the Republic of Indonesia. Internal peace has not yet been restored and the export of plantation products is still much below the pre-war figure. Whether the pressure of population on the land in Java will make estate production at the pre-war level again possible remains to be seen, but the unworked potentialities of sparsely populated Sumatra and some of the other islands are enormous.

The introduction of tea into Java began in 1690 when Camphys, the Governor-General, planted the first tea as a matter of interest. In 1728 the Dutch East India Company considered the planting of tea but it was not till 1825 that the industry began, with the import of seed from Japan. By 1835 about 2 million plants had been put out, largely due to the zeal of J. J. L. L. Jacobson, in the service of the Company who had become one of the greatest experts on tea at that time. In 1838 the Government opened an establishment in Batavia for finishing tea, in accordance with Chinese procedure, but the losses on the venture became so serious that in 1860 Government abandoned its direct connexion with tea planting and preparation.

In 1872 Assam seed was first imported but real success was not obtained till 1878, the same year that hand manufacture was replaced by machinery, whereby a considerable improvement in quality was effected. Seed was also imported from Ceylon but since the plants proved scarcely different from those grown from 'Java' seed (as the imported China and Japan bushes grown in Java came to be known) the experiment was given up. It is likely that the Ceylon seed itself first came from Java. The present tea stand in Java is practically wholly of the Assam type.

In 1882 the Soekabocmi Agricultural Syndicate was formed to

take care of planting industries in Java and in 1890 the Government began to encourage tea production. There was no tea market in Java comparable with those of London, Calcutta or Colombo, so a Tea Export Bureau was formed in 1905, first at Soekaboemi, then at Bandoeng and later at Batavia. This Bureau reported on the teas and gave advice regarding market requirements. The teas were either sold privately in lots in Batavia, Java or Medan, Sumatra, or else sent to London or Amsterdam for auction. Since the war a market has been opened in Djakarta which in 1952 dealt with over 24 million lb. tea

The Dutch scientists in Java always held a leading place in the tea world and the earliest systematic work was carried out there from about 1890 onwards. In 1902 a Tea Experiment Station was founded at Buitenzorg and in due course one was opened at Medan in Sumatra.

By the end of 1928 there were 235,000 acres of tea planted in Java. In Sumatra, in the north-eastern part of the island near Belawan Deli, opening began in 1911 and by 1928 no less than 53,000 acres were planted. In 1929, Java exported 138 million lb. tea and Sumatra 23 million lb., a total of 161 million lb.

Under the International Tea Regulation Schemes, whereby exports are agreed upon and extensions of acreages controlled, the Dutch East Indies, as they were then, were allowed an acreage of about 540,000 and a Standard Export quota of 174 million lb. tea per annum.

The table below shows the estate acreages for 1941 and 1952 in Java and Sumatra, and the area planted by peasants who sold leaf to estates, together with the output of those years. The differences are some indication of the losses suffered during the war years and since. The year 1941 witnessed record production.

TEA PRODUCTION IN INDONESIA, 1941 AND 1952

	1941		1952	
	<i>Acres</i>	<i>Production million lb.</i>	<i>Acres</i>	<i>Production million lb.</i>
Estates, Java .	263,118	122	159,319	47
„ Sumatra	82,390	44	34,209	20
Peasants, Java .	184,981	88	—	15
Total	530,489 acres 194 mill. lb.			82 mill. lb.

The figures for peasant holdings are very incomplete for 1952 in Java whilst there are no records for such areas outside Java. The hand-prepared tea, consumed locally, is estimated at about 10 million lb. per annum. Thus in 1941, in all, over 200 million lb. tea were produced, of which 167 million lb. were exported. The Dutch East Indies were then third in importance of the tea exporting countries, following India and Ceylon which together exported 539 million lb. In 1952, Indonesia exported 70 million lb. tea, still occupying third place but very far behind India and Ceylon which in that year exported 803 million lb. between them.

Methods in Indonesia

The rehabilitation of Indonesia will be a slow process without the aid of foreign capital and staff, and any description of methods employed necessarily refers to procedure when the Dutch were in control of the tea estates.

Whilst the actual lie of the land in the Java tea districts resembles that in Ceylon, the slopes are less steep. As a rule, little tea is grown at low elevations and most estates might be classed as mid- and up-country. The tea soils of Java are of volcanic origin and in some cases of recent formation. They are deep soils, rich in nitrogen and potash. The Sumatra tea soils are of similar origin and make-up but usually much lighter. In Java, much of the tea is contour planted and great care is taken to avoid soil wash and exposure to the sun.

Field methods resemble both those in Ceylon and Assam. Thus, stumps from the tea nursery are used for planting as in Ceylon, whilst pruning resembles that followed in Assam with a higher cut than in Ceylon. On the other hand, plucking is above a leaf early in the cycle, in the Ceylon manner, although later it is down to the *janam*.

The bushes are planted $3\frac{1}{2}$ ft. by 4 ft. and as a result a very close cover is obtained. In addition a high, dense shade canopy of leguminous trees is grown which with the help of the tea bushes reduces markedly the weed growth. Selective weeding is practised and deep cultivation is seldom employed.

Regarding the factories, buildings and quarters, before the war many of these were in advance of those generally seen in India and Ceylon. Many estates had their own hydro-electric

schemes, others took power supplied by the Government. The factories and their surroundings were beautifully kept and laid out in a spacious manner.

Withering was done in highly controlled lofts, in twelve to eighteen hours, with leaf spread on wire racks at 1 lb. to 10 sq. ft. The degree of the wither was down to 60 per cent and when possible, the air was sent into the loft at 73° F. with a wet bulb depression of about 7°. The Bosscha withering machine, mentioned in the chapter dealing with methods in North-East India, was still in use in some Java factories before the war. Rolling and fermentation were usually done in the same air-conditioned room, with four rolls. The temperature preferred for fermentation was 72° F. A single fire was given, taking about thirty minutes, with an initial temperature of 210° to 225° F. and an exhaust of 120° to 130°. Grading was a feature of Java and Sumatra teas, and many ingenious machines were invented for the purpose.

The factory details given above are well known for they have resulted from decades of experience and endless observation, and have been discussed and written about for the past fifty years. The same may be said of the management of the soil and the treatment of the bush. Nevertheless, it seemed that the rules of tea planting and manufacture were more meticulously followed in the Netherlands East Indies before the war than either in India or Ceylon.

Since the War, tea in Java and Sumatra has been subject to Blister blight and this has been fought energetically on European-owned estates. The quality of much of the tea produced recently has been disappointing, partly owing to insufficient equipment, long-range leaf transport and poor leaf.

Tea in Malaya

As soon as tea had been successfully grown in Ceylon, planters tried the crop in Malaya, as early as 1874 in the Province Wellesley, opposite Penang, and near Singapore. It was at that time stated that only the Assam plant should be grown and that there were millions of acres suitable for tea. But for the fact that rubber has been such a success in Malaya, the tea industry might have been developed there on a large scale.

The Chinese in Malaya have grown China-type tea in small

holdings for many years in a rough and simple manner. The leaf is prepared by hand and pan fired. In 1940 the acreage of such small holdings was reckoned to be 533, but the present area is said to be negligible.

In 1925 a Tea Experiment Station was opened at Serdang, near Kuala Lumpur in the State of Selangor, and later one was started in the Cameron Highlands, at the eastern end of Tanah Rata, at an elevation of 5,000 ft. At this altitude, extreme day and night temperatures range from 77° to 45° with average maxima and minima of 70° and 50° F. The annual rainfall is 100 in., well distributed.

Methods followed both in the field and factory resemble those in Ceylon. In both the low country about Serdang and in the Cameron Highlands a yield of 500 lb. tea per acre is expected in the fifth year from planting and 1,000 lb. in the tenth year, with the help of fertilizers. Both the Assam and Burma type of bush do well in Malaya.

By 1932 the area planted to tea was about 2,400 acres, which increased to over 9,000 by 1940. At present there are about 10,000 acres planted of which more than half are in the Cameron Highlands and over a quarter in the State of Selangor. There are small areas in Perak, Kedah, Malacca and Johore. Most of the estates are European-owned.

In 1953 the total production was 4·19 million lb. of which 4 million lb. was black tea and the balance green tea. The export of tea started in 1930 and by 1940 it had risen to 0·66 million lb. After the war exports started again and in 1953 they had reached 2·18 million lb.

The climate of Malaya is equable and at Serdang the rainfall averages 93 in. per annum, with August, the driest month, receiving just over 3 in. and November, the wettest, over 12 in. Malaya with its hot, humid atmosphere is suited by nature to grow tea and large yields can be produced. The even climate is against the making of quality teas but with the use of our present knowledge on tea selection this handicap could be reduced or overcome.

Tea in Indo-China

As might be anticipated, tea has been produced by the peasants of Indo-China for many centuries in the Chinese manner.

The holdings are mainly in central Tonking and central Annam and the acreages in the two areas have been estimated at 8,000 and 60,000 respectively. The bushes are plucked three times a year and the product, both black and green tea, is consumed locally.

In 1925 the French Government encouraged the development of tea growing on plantation lines with modern methods and equipment. Estates were developed in the Kontum area, south of Tourane and in the Dalat Hills near Nhatrang. The tea near Kontum is planted mainly on flat land at about 2,400 ft. altitude although some has been planted in low country. The Dalat plantings are at about 5,000 ft.

The climate in Annam resembles that in the Uva district of Ceylon and the winter is dry and cool. The Assam type of bush, grown from seeds imported from Java, is employed. In the wet season plucking is on a seven to ten-day round, but in the dry season the rounds extend up to twenty days. The factories are of the most modern type, planned in the Java style.

Indo-China, in common with every other country in South-East Asia, experienced the ravages of the recent war and subsequent unrest, although the peasant holdings have apparently suffered more than the large estates. Accordingly the latter have been able to dispose of much of their product internally and have gone over partly to green tea manufacture. Production by the estates totalled a little over 1 million lb. in 1948 rising to over 3 million lb. in 1953.

In 1940 the export of tea reached its peak figure of 5.4 million lb. after which it decreased and then practically ceased till 1946, since when the figure has fluctuated between $\frac{1}{4}$ and 2 million lb.

The natural tea belt includes the Annamite range and wild tea has been found in many places in Indo-China. The natural habitat of a plant is not necessarily the best place for its economic development, yet it is evident that a useful branch of the tea planting industry could be located in this country.

Tea in the Shan States

Although China is the home of tea and it is usually assumed that tea, either as a medicine or beverage, originated there, it is quite possible that the primitive peoples living in the highlands

of Further India, the natural habitat of the big-leaved type of tea, may have used the plant in some form or other at a still earlier time than the Chinese.

The people occupying the Shan States of China, Burma and Siam prepare tea in a simple manner by steaming the leaf and burying it wet in a pit or ramming it into a bamboo. This pickled or silo-ed tea is an article of commercial importance in Burma and Siam. Green tea is also made in the Shan States and that from South Yunnan, China enjoys a considerable reputation for its alleged medicinal and digestive properties.

In Burma, the pickled tea is called *leppet-so*, whilst dry or green tea is called *leppet-chauk*. In Siam the Lao tribes pickle the leaf which is called Lao tea or *miang*. In South Yunnan the dry tea is called Pu-erh tea, after the town of that name although it is grown and prepared in the I-Bang district.

In Siam, *miang* tea is grown mainly in the hills to the north and east of Chiangmai. In Burma, the area under tea in 1949 was estimated at 35,000 acres most of which is in Tawngpeng State. Some tea is grown in the Southern Shan State of Kengtung and some in the Katha district. In the north-west of Burma, at Homolin and Tamanthe on the Chindwin, tea leaf is prepared and Robert Bruce, the pioneer of tea in India, first heard of the preparation of pickled tea by the Singphos who occupy the upper reaches of this river.

The inhabitants of Tawngpeng, one of the Northern Shan States, are Palaungs. The State is a mass of hills 3,000 to 5,000 ft. high and the capital Namhsan, situated at 5,500 ft. is seventy-five miles by road from Kyaukme, which is on the railway 490 miles from Rangoon. Kyaukme is the mart for pickled tea made in Tawngpeng and there are forty to fifty brokers dealing in the commodity.

In making pickled tea, the leaf is first put into a wooden container with a plaited bamboo base, which is placed over a vessel of boiling water. After five to ten minutes of this treatment the leaf is thrown on to bamboo mats and kneaded for ten minutes. The leaf is then placed in a pit 5 to 6 ft. in diameter and 6 ft. deep. The pit is often of cement and is lined with bamboo matting and plantain leaves. Steamed and kneaded leaf is added as it is prepared and the contents of the pit are pressed down by planks weighted with stones. The leaf

may be left in the pit for a period varying from ten days to six months or more. When it is removed it is still wet and bright green in colour, but if exposed to the air it soon becomes dark and turns mouldy.

Leppet-so has the smell of wet organic matter which has decomposed in a limited air supply, as of retting jute. It also has a distinct leathery smell and a slight sweet smell as of alcoholic fermentation. The whole aroma is not unpleasant and might easily become an acquired taste. *Leppet-so* is washed in salt water before it is eaten and is taken as a salad, mixed with oil, garlic, dried prawns, &c.

For export, *leppet-so* is packed in bamboo baskets in lots of about 100 lb. with the inside of the basket smeared with cow-dung and lined with leaves. When small quantities of leaf are pickled for home use it may be rammed into a bamboo. There are many qualities of pickled tea, depending on the time of plucking, the part of the pit in which it was pickled and so on.

Leppet-chauk or green tea is made first by steaming, as with pickled tea, after which the leaf is rolled on a bamboo mat and then dried, preferably in the sun. The best tea is made in March, April and May before the monsoon breaks. The most satisfactory way to deal with the harvest is to make green tea early in the year and pickled tea in the rains. There are as many qualities of green tea as there are of pickled tea. Green tea is usually sold in bazaars from sacks, but sometimes it is packeted.

Burma is undoubtedly a country where tea could be grown in plantations. In 1923 an estate on modern lines was started at Thandaung in Lower Burma, thirty miles from Toungoo, in the Karen Hills at an altitude of about 4,500 ft. Toungoo is on the main line 170 miles from Rangoon.

The country in this area resembles that in the Western Ghats of South India. There is only one monsoon, of course, and the rainfall is torrential with a total of 275 in., most of which falls from May to September. The monthly mean temperature varies from 74° F. in May to 66° in December, a range which is not wide enough to stop growth in the dry weather, so the crop is harvested all the year round albeit at an irregular rate. This property was not reopened after the war.

In Namhsan a British-owned factory was built just before

the war, equipped to make black tea in the modern manner, with leaf purchased from small holders. The factory was damaged during the war but has since started up again. In 1947 production was nearly 120,000 lb. and it has steadily increased since to almost 1 million lb. The outturn is sold in Burma.

Tea in Papua, New Guinea and Queensland

The enormous island of New Guinea is divided into two parts, the western under Dutch suzerainty and the eastern under Australian. The southern area of the Australian portion is known as Papua. It is considered that much of the land is suited to tea culture. A year or two ago, 90,000 seedlings, raised from Malayan seed, were put out at Garaina and Government proposes to set up a factory there as an experimental undertaking.

Tea will grow well in Queensland, Australia, but the high cost of manual labour puts it out of court as a producing country till mechanical planting and harvesting are possible. The areas where tea could be cultivated are in the sugar-growing districts ranging from Mossman, nearest the equator, down to Mirriam Vale. Tens of thousands of acres are considered suitable.

In Murray Valley, near the Tully Falls, the rainfall is over 100 inches and in the Innisfall Cairns or Daintree districts it varies from 60 to 140 in. It is thought that a people who evolved competitive methods of producing rice, sugar and cotton by highly paid white workers can do the same with tea.

In 1953 Australia imported 61 million lb. tea of which 52 million lb. came from Ceylon, 4 million lb. from India and 2 million lb. from Indonesia.

CHAPTER XIV

TEA IN NORTHERN INDIA AND THE MIDDLE EAST

*Tea in Ranchi—Dehra Dun—The Kangra Valley—Iran—
The U.S.S.R.—Turkey.*

THE distance between Ranchi, Bihar and Batoum, Caucasia near which town the tea areas of the U.S.S.R. and Turkey are located, is about 3,000 miles and it may be asked why this attenuated string of ill-assorted tea areas are considered together. The similarity between them lies in the fact that they only grow tea with difficulty, and generally the hardy China or China-hybrid types must be planted rather than the large-leaved Assam and Burma types. The commodity produced in the countries about to be described does not directly compete with tea in the general market.

Tea in Ranchi

Ranchi is situated on the Chota Nagpur plateau in the province of Bihar, 200 miles westward of Calcutta and hence out of the track of the moist air draft which passes into North-East India to alleviate the pre-monsoon drought. Some account of the climate of Ranchi is given in Chapter II, together with figures relating to crop distribution.

The area is about 2,000 acres of the China type which is dwindling owing to the difficulty of replanting. The average yield is below 200 lb. although some good sections give up to 400 lb. tea per acre. The bushes are pruned every third year about mid-May but little crop is obtained that year before October and by the end of the year 40 lb. tea per acre may be harvested. The second year, provided the early months are not too dry, the unpruned tea may give 400 lb. and the following year, again unpruned, 250 lb. per acre. Weeds give little trouble and a soil mulch is essential in the dry season, but even then it

dries to a depth of over 1 ft. Shade is provided by mango, toon, sirris, sau and many other trees. Green manures and artificials are used. Pests and diseases have no economic importance and are evidently kept in check by the severe drought.

Practically the whole crop is made into green tea. When the leaf is brought to the factory it is steamed for two minutes in a revolving wooden drum, then put into a hydro-extractor which removes the superficial moisture. Rolling for half an hour follows, then the leaf is fired till it contains about 50 per cent moisture. A second roll is given, after which the drying is completed. The leaf is polished by placing it in a steam-heated revolving cylinder with powdered soapstone. Polishing is done for three hours before and five hours after sorting. The tea so produced finds a ready market in Calcutta.

Tea in Dehra Dun

Dehra Dun is situated in the Uttar Pradesh or United Provinces, at the western end of Nepal, 650 miles from the Bengal Terai at the eastern end of that country. Dehra Dun is 800 miles from the Bay of Bengal and the same distance from the Arabian Sea, so that part of the monsoon rain comes from the Bengal current and part from the Bombay side. The proximity of the Himalayas profoundly influences the climate of the Dun, making it cooler and more humid than the plains a few miles away on the other side of the Siwaliks.

The tea estates are all situated in the *dun* or valley between the Himalayas and the Siwalik Hills. These hills which are composed of rocks washed down from the Himalayas, first formed the plains and then, on account of the lateral thrust as the Himalayas advanced southwards, were pushed up to form a range of hills near the mountains. The valley between the two ranges is about 2,000 ft. above sea level and the Siwaliks rise another 3,000 ft. to the south. To the north of the *dun* are the Himalayas with the hill station of Mussoorie at 7,000 ft. and beyond, the snows.

Dehra Dun is one of the historic areas in tea development. The Committee appointed by the Governor-General of India in 1833 to consider the question of tea growing, recommended the lower hills and valleys of the Himalayas. In 1840 a Government tea plantation was accordingly opened at Kowlagarh

near Dehra Dun. In 1851, Robert Fortune, at that time an authority on tea in China, inspected Kowlagarh and reported unfavourably on the site and the tea and condemned irrigation, apparently on the ground that it was unnecessary in China. Present experience in Dehra Dun shows that irrigation is harmful on account of the alkalinity of the water in some of the streams. The area planted to tea is about 6,250 acres.

The tea is planted on flat land in the *dun* and is commonly shaded with the shishum, *Dalbergia sisso*. The crop averages 500 lb. per acre and is practically all made into green tea. The leaf when brought in is thrown into iron pans, heated to dull redness, and stirred. In this way a quantity of 15 lb. leaf loses about $2\frac{1}{2}$ lb. moisture in three or four minutes and turns an olive green. Rolling in ordinary rollers then takes place after which the leaf is partially dried in the sun or, in dull weather, fired just short of crispness in a dryer. Another roll is given, followed by a final fire. The tea is sold in bulk at the factory door, after a little bargaining, then taken by road in sacks to Amritsar, the tea mart for the North-West, where it is sorted and repacked for Kashmir.

The rainfall in Dehra Dun averages 78 in., against 55 in Ranchi. The spring in Dehra Dun is not so hot and dry as on the Ranchi plateau but there is still a shortage of rain in May which causes the bush to stop flushing in that month, or to grow very slowly until full monsoon conditions are established in June. The tea grown is generally of the China-hybrid type, but the Burma bush can also be made to thrive with generous treatment.

Tea in the Kangra Valley

The Kangra Valley is situated in the Punjab 200 miles from Dehra Dun. The Valley is in the foothills of the Himalayas and the main tea area is near Palampur, seventy miles from Pathankot at the entrance to the valley from the plains. The Kangra Valley is connected with the Kulu Valley, renowned for its orchards.

Tea cultivation began in 1860 when land was offered for tea and largely taken up by British officers. The prolonged slump in tea prices about 1900 and the earthquake in 1904 drove most of the British owners from the district. The tea is mostly

of the China or China-hybrid types, although the big-leaved varieties have been cultivated with success. The rainfall at Palampur averages 100 in., but the distribution is poor, with a hot, dry spring so harmful to the bush when it is producing the first flush.

The leaf is made into green tea and the preliminary heating is carried out in iron pans. The product is sent to Amritsar for distribution. The area planted to tea is just under 10,000 acres.

Tea in Iran

Much of Iran is dry, arid plateau but a small strip of land in the north, between the Caspian Sea and the mountains which bound the Iranian plateau, has an average rainfall of 50 to 60 in. where tea of the China type can be grown commercially. The winter is cold however, with abundant snow and frequent frosts, whilst the spring is hot and dry.

Tea was introduced into the country in 1898 by the Iranian Consular representative in India at that date. By 1932 the area under cultivation was still only 3,000 acres but since then it has risen to 27,000 at present. More than half the total outturn is produced in the province of Gilan and the balance in Shahsavari. There are very small areas in Astara and Mazandaran. The total yield in 1953 was estimated at 12 million lb. which gave an average of 440 lb. tea per acre.

The tea is put out in small holdings and the leaf sold to modern, well-equipped factories. However, field work leaves much to be desired and prejudices regarding pruning, weeding and plucking have to be overcome before this country can succeed as a tea producer. The pruning is severe, because it is thought that too much foliage left on the bush dries out the soil. Weeding consists of hacking and hoeing which destroys non-noxious weeds without controlling grasses. Mulching is neither understood nor practised. The chief fault comes in plucking, for the bushes are stripped of the spring flush and very little can thereafter be harvested in the summer and the autumn. These errors in field operations are not peculiar to Iran.

The factories struggle with bought leaf over which the factory owners have little control. This problem arises wherever bought leaf is dealt with. There is an experimental factory at Lahijan, in the province of Gilan.

Tea in the U.S.S.R.

At the eastern end of the Black Sea in the Poti area of the province of West Georgia, near Batoum tea can be grown. It was first introduced in 1892 and by 1900 about 2,000 acres had been planted. By 1925 the area was still no greater than 3,000 acres of which 1,000 were peasant holdings. In 1927 the Government took a hand in development and by 1940 about 131,000 acres were under tea and the production was over 28 million lb. By 1950 the area was 140,000 acres and production 40 million lb. The goal for the Fifth Five-Year Plan, 1951-5 is 220,000 acres. In the province of Azerbaijan, adjoining northern Iran and running to the Caspian, collective and state farms are growing tea. The southern areas of Krasnodar Territory near the Sea of Azov are being planted, whilst the Transcarpathian region of the Ukraine, parts of the Moldavia and the Crimea are under experiment. Research work is being conducted to consider the crop in certain districts of Central Asia.

The climate of Poti was described in Chapter II. It is by no means ideal for tea and the Burma and Assam types of plant fail there, although the China bush succeeds. In the main tea growing district of Georgia the average crop is 520 lb. tea per acre, but crops up to 1,000 and 1,400 lb. tea per acre are claimed for some areas.

The seed was obtained from Japan, China and India, the last being preferred, coming from the Darjeeling district where a good China-hybrid is grown. The tea is hedge-planted with a view to mechanical plucking and the leaf is manufactured with modern machinery in up-to-date factories. Black tea is made.

The scientific study of tea culture is actively proceeding in the U.S.S.R. the main distinctive work being connected with the selection of bush types suited to the climate. When such have been established no doubt bigger average crops than at present will be made and teas of high quality produced.

In the field, experiments with mechanical pluckers have gone a long way. The plucking shears used in practically all the Japanese tea holdings have been tried, but tea plucking machines which move over the surface of the bushes with wheels on the ground, have been under experiment for over

twenty years. The latest model works on the comb principle with mobile and immobile teeth, the former are rubber-covered and press against the young twigs to snap them off. An even pluck is not obtained of course, for such is not possible by mechanical means, but 80 to 85 per cent good leaf is harvested with the balance consisting of coarse leaves and twigs.

The findings by the U.S.S.R. scientists with regard to types of bush able to withstand harsh climates and the results of trials of plucking machines in the Soviet Union, will be followed with great interest. If a hardy, high-yielding, quality bush can be selected, the areas in the world capable of producing economic tea crops will be greatly extended, whilst the production of a successful plucking machine would practically solve the labour problem in countries like Queensland, Australia.

Tea in Turkey

In Turkey, tea is grown in the Rize area on the Black Sea, 40 miles from the Soviet frontier and seventy-five miles in a direct line from Poti, chief centre of the tea industry in the U.S.S.R. In 1952 the area allotted to tea culture was 14,000 acres and 9,500 were in cultivation. The total production in that year was just under 1 million lb.

Although modern factory equipment has been installed, the small holder has not adopted modern methods in the field and as in Iran, much remains to be done in this direction.

CHAPTER XV

TEA IN AFRICA

The development of tea planting in Africa—Climate of African tea areas—Field methods—Manufacture—Labour and organization.

IT might be considered that the opening up of tea lands in Eastern Africa is only an extension of activities in Asia, but there are fundamental differences between the two which justify the assumption that the development of the industry in Africa may be described as the third phase in the history of tea culture. This aspect of the subject is pursued in the next chapter.

The Development of Tea Planting in Africa

Experimental tea plants were put out in the Botanical Garden at Durban in 1851. In 1887 seed was imported from Assam and put out at Kearnsey, near Stanger about forty miles up the coast from Durban and the area was in due course extended to about 4,000 acres. Modern methods were not employed and the planted area gradually diminished till in 1948 the remainder was abandoned or replaced by sugar, which is the main crop of this district. The rainfall along the coast is about 45 in. which falls largely in the southern summer months, October to March. It is likely that with the correct field methods and a suitable Burma type of bush, tea would flourish in this area.

In Nyasaland, missionaries tried to establish tea in Blantyre in 1887. This was about the time the China tea trade touched its peak, and just before India and Ceylon began to take control of the industry. Commercial production began in 1900, with Henry Brown in Mlanje as pioneer. Today 25,000 acres are under tea in the Mlanje and Cholo districts, to the

south of Blantyre. The former tea area is at 2,000 ft. altitude and the latter averages 3,000 ft. Crops of 1,200 lb. tea per acre are common. The potential area for tea is considerable, and on part of the Vipya Plateau, half way up the western side of Lake Nyasa, preliminary trials show promise. The early planting was unfortunately with the China-hybrid type of bush grown from seed imported from Ceylon and Lebong, Darjeeling but later planting was with seed of the Shan and Burma types. Local gardens now produce seed of types suited to the country.

Tea growing in Kenya is a more recent venture and planting on a commercial scale started in 1925. Since then the industry has steadily expanded and in 1952 about 22,000 acres were planted and licences to plant over 58,000 had been granted. At Kericho, in the Kenya Highlands, altitude 6,000 ft., a magnificent stand of tea is grown. Both Shan and Burma types are planted.

In Uganda, the Government introduced tea seed from India in 1900 but it was not till 1916 that a commercial start was made at Kakonde Estate, Mityana. The area under tea has steadily expanded from 2,000 acres in 1935 to nearly 8,000 acres in 1952.

Tea was planted in Tanganyika by the Germans after the First World War. The original plantings were in the Mufundi area with hybrid seed but now the large-leaved types of bush are grown in this and other areas of the Territory. There are three tea districts, Mufundi and Rungwe, both in the south, the former in the Southern Highlands at 6,000 ft., and the latter between the northern end of Lake Nyasa and Mbeya at 4,000 ft. The other area is in the north in the Usumbara Range at 3,500 to 5,000 ft., near the coast and the southern border of Kenya.

In the Belgian Congo tea is being planted in the Ruanda district, mostly in the mountainous area around Lake Kivu, and over 4,000 acres have been put out. A research station has been opened at Mulungu and a number of co-operative factories for small holders have been erected.

The tea industry in Portuguese East Africa (Mozambique) has great potentialities. In 1935 the area planted was a little over 2,000 acres whilst today it is more than 26,000 acres. There

are three districts, Milange, adjoining the Mlanje district of Nyasaland, Tacuane and Gurué, which last two lie to the east and north-east of Milange. Some planting has also taken place much further south on the border of Southern Rhodesia near Melsetter. Most of the early tea planted was of poor variety, from so-called Nyasaland 'local' seed which is China-hybrid, but better stock is now being used.

There is a small but thriving area under tea in Southern Rhodesia in the Melsetter district. A start was made in 1927 at New Year's Gift, which estate is irrigated and some account of conditions here are given in Chapter II. Three other estates have been opened, total acreage about 1,500 with a present production of over 1 million lb. tea. The adjoining area over the Mozambique border, mentioned in the previous paragraph, can also grow tea. The Inyanga area, about 100 miles north of Umtali, is being opened to tea. The Shan and Burma types of bush do well in Southern Rhodesia.

Tea could be grown on the West Coast of Africa and a start was made in the Cameroons at Tolo when 70 acres were planted some years ago. Interest has now revived and it has been decided to open up 700 acres. Tolo is on the south-east slopes of the Cameroon mountains 2,000 ft. elevation, with a rainfall of 100 in. and a dry season from December to February inclusive. Both Shan and Burma types have been planted.

The tea in the island of Mauritius is generally included with tea in Africa. This British Colony lies some 1,400 miles from the African coast, latitude 20° S., longitude 57° E. The island is forty miles long and thirty miles wide. Tea planting started in 1883 with hybrid seed but recently better types have been imported from Malaya. The acreage is about 2,500 but the shortage of land and the high costs of production are against expansion. In 1953 about 77,000 lb. tea were exported but most of the crop of under 1 million lb. is consumed locally.

Thus in Eastern Africa tea is planted from the equator, about which the Kericho area in Kenya is located, to 20° S. in which latitude the tea in Melsetter, Southern Rhodesia stands. From Kericho to Melsetter the distance is 1,500 miles. In the table below the various tea areas are denoted, ranging from north to south, together with production in 1952.

AFRICAN TEA AREAS AND PRODUCTION IN 1952

<i>Area</i>	<i>Acreage</i>	<i>Production million lb.</i>
Kenya	21,011	14.8
Uganda	7,798	3.8
Belgian Congo	4,302	1.0
Tanganyika	10,493	2.5
Nyasaland	23,179	15.6
Portuguese East Africa	26,393	7.8
Southern Rhodesia	1,512	1.0
Mauritius	2,368	0.9
Total	97,056 acres	47.4 million lb.

How far the industry in Africa will expand is impossible to say for a number of factors are involved. The plantable area is many times that already opened, whilst with modern field methods and selected types of bush, outturns of over 1,500 lb. per acre can be realized in some areas. Similarly, with the right kind of bush, teas of quality and flavour can be and indeed are produced in Africa.

The Climate of the African Tea Areas

No doubt tea can be grown in many parts of Africa in addition to those detailed above and it is surprising at first sight why the extension has not been more rapid. However, African conditions are different from those which held in India and Ceylon when those countries were opened up. Assam was a sparsely populated land of jungle and swamp, whilst the hills of Ceylon and South India were practically unoccupied by peoples of those countries. Much land in Africa well suited to tea is under native cultivation and the African scratches a bare subsistence where he could earn enough to live in plenty were the soil under tea. Yet no man wants to give up the land he tills and the plot where his house stands just to become a worker for a company, however much better off he may be for the change.

Broadly speaking, the African tea areas may be divided into two groups according to their climates, those north of latitude 5° S. which have two wet seasons, and those south of this

latitude which have only one wet season. In Chapter II, the average monthly rainfall at Kericho was shown as indicative of the distribution of rainfall and crop in what may be called the Equatorial tea belt of Africa, which includes Kenya, Uganda, the Ruanda district of the Belgian Congo, and the Usumbara Range near the coast in the north of Tanganyika. The monthly average temperatures in all these districts show little variation and the crop is well distributed throughout the year.

The tea areas south of latitude 5° S. may be said to form the Nyasa tea belt where only one wet season occurs. These districts form a crescent around Lake Nyasa, starting with Mufundi and Rungwe in south Tanganyika, the Vipya on the western shore of the lake, Cholo and Mlanje in the Southern Province of Nyasaland and Milange, Tacuane and Gurué in Portuguese East Africa. Both the Inyanga and Melsetter tea districts in eastern Southern Rhodesia also have only one wet season. In all these areas the wet period, November to March, is also the warm one and during these months three-quarters of the crop is made. In the dry period the fall in temperature compared with that in the wet is insufficient to cause the bush to winter and stop flushing completely, although the rate of growth is very slow in July and August. In the dry weather in Nyasaland moist winds called 'chiperones' bring rain up to July and thereby mitigate the severity of the drought.

Field Methods in Africa

Very little analytical data about African tea soils is available compared with the enormous mass accumulated on those in India, Ceylon and Java. In view of the scanty practical information given by chemical analysis, this lack of data need cause few misgivings. The fact that tea requires a wet, warm climate ensures that mature soils in tea areas will have weathered so as to show certain characteristics. Tea soils are leached soils, poor in lime and other bases, and acidic in reaction. They are latasols and are often described as lateritic soils.

The tea crop in Africa as elsewhere responds to applications of nitrogen, and sulphate of ammonia is added in generous quantities, giving up to 120 lb. nitrogen per acre. Many tropical and sub-tropical crops respond in the same way, including rubber, tobacco, tung, citrus and maize. So far no

marked response has been obtained from potash or phosphoric acid in African tea estates, but additions of these minerals will no doubt be necessary in due course.

Trace elements are as important as nitrogen, potash and phosphates and retard or stop growth if withheld from the plant. In Nyasaland some areas, especially those with black soils, are short in available sulphur and the young tea suffers from a leaf condition called Yellows which is usually thrown off as the plant gets older. There is also one instance in Nyasaland of copper shortage or non-availability, and the leaf harvested from such soil fails to ferment, apparently because it lacks the copper-protein which constitutes the enzyme. Both these points have been referred to earlier, in Chapter III.

Many planters from Assam, South India and Ceylon have had a hand in opening up tea in Africa and methods include those used in all these countries. The plant is lifted from the nursery as a stump, the bush is formed by cutting across at 18 in. and plucking is at about 30 in. to a flat table. A three-year pruning cycle is common.

The value of shade trees is fully recognized and their effect is similar to that in Assam, where a canopy which reduces the light intensity by about 50 per cent may increase the crop by as much as 640 lb. tea per acre. A common shade tree in Nyasaland is the local chikwani, *Albizzia gummifera*.

Tea Manufacture in Africa

There are many fine factories in Africa, often constructed on Ceylon lines, with spacious, well-controlled withering lofts. The full wither, long roll and single fire as practised in Ceylon are often used, although where temperatures and equipment do not allow of this, the light wither, short roll and double fire of Assam are employed. The atmosphere in Eastern Africa seems to be generally less humid than that in India, Ceylon or Java, and in many areas, especially in Nyasaland, natural withering conditions are often rapid.

Much valuable experimentation has been carried out in African tea factories. The Mobile-tat for withering was developed in Africa, and this is perhaps the ultimate conclusion to the controlled wither, if the optimum time, temperature and speed of the process are to be maintained. On the other hand

Drum withering, whereby most of the physical wither is developed in a two or three-hour period is under experiment on factory scale. Attempts to cut out the wither altogether have led to trials with expressors. In another series of useful experiments, the leaf has been chilled or frozen in order to make it flaccid for rolling. The submission of the leaf to a vacuum as a means of limping it for rolling has been tried. Tobacco-cut, non-wither teas have been the subject of exhaustive trial and experiment. However as with experience elsewhere, it is generally found that to get normal tea, normal procedure must be followed.

Labour and Organization

African labour is a shifting population and very different from that on Indian and Ceylon estates. Nevertheless the African is a good worker, well paid and cheerful, and the tasks he performs compare favourably with those done in India and Ceylon. Female labour is not generally employed in tea estates.

There are Tea Associations in Kenya, Uganda, Tanganyika and Nyasaland. There are Government research stations at Mlanje in Nyasaland, opened in 1932, and at Kericho in Kenya, started in 1949.

There are no tea markets in Africa comparable with those in Calcutta, Chittagong, Cochin or Colombo, but private sales are negotiated with dealers all over the world. The port for Kenya and Uganda is Mombasa, which is 521 miles by rail from Kericho and 878 miles from Kampala in Uganda. The Usumbaras district in northern Tanganyika is connected by rail to the port of Tanga, about fifty miles away. The Mufundi and Rungwe districts are 160 and 300 miles respectively from railhead, whence the port is Dar-es-Salaam.

The Cholo and Mlanje districts of Nyasaland and the Milange district of Mozambique, send the tea from the nearby rail at Luchenza to the port of Beira, a distance of 330 miles. The Tacuane area in Mozambique has a railhead at Mocuba, whence the port of Quelimane is reached. The Gurué district sends the tea by rail to the port of Mozambique.

PART III
THE TEA TRADE

CHAPTER XVI

THE DEVELOPMENT OF THE TEA INDUSTRY

Phases in the development of the industry—The East India Company—The tea plantation industry—Public tea auctions.

ACCOUNTS of the earliest days of the tea trade often differ in detail and in date. The first consignment of tea was brought to Europe by the Dutch in 1610 who got it from the Chinese in exchange for dried sage. The Dutch began importing tea thereafter and it was introduced into England about 1645.

Tea was first sold publicly in England in the year 1657 at Garroway's Coffee House, a centre of mercantile transactions in Exchange Alley, in the City of London. The next year, for the first time, tea was advertised in the London newspaper, *Mercurius Politicus*, as obtainable at the Sultan's Head Coffee House in Sweeting's Rents, by the Royal Exchange.

At the coffee houses, the tea was brewed and kept in a cask from which it was drawn and warmed up. The drink soon gained popularity and a tax of 8*d.* per gallon is said to have been levied in 1660. Since then, taxes on tea in some form or another have been imposed with resultant complications and difficulties to trading.

Phases in the Development of the Industry

The development of the tea industry, so far, falls into two distinct phases, whilst a third and probably a fourth phase are now taking shape.

The first phase began in China when the Dutch exported tea to Europe in 1610, and expanded into the China tea trade which reached its peak in 1888, and is still a big factor in normal times. In this phase Europeans have been connected only with the trade in the commodity, purchased at the ports

and shipped to the countries where it is distributed and consumed.

The second phase began in Java in 1825 and in India in 1833, where the industry was developed with a view to production as well as trade. India soon went ahead but Java only began to become an important producer in 1900. Ceylon entered this phase in 1875 and Sumatra about 1910. Before the War disturbed South-East Asia in 1942, India, Ceylon and the Netherlands East Indies had planted up to over 2 million acres to tea, whilst in 1941 these three areas produced no less than 945 million lb. tea.

The basis of the industry in Africa differs from that in Asia and it is justifiable to consider development in this continent as a new phase, which began in Natal in 1887. The countries concerned in opening tea lands are, from north to south, Kenya, Uganda, the Belgian Congo, Tanganyika, Nyasaland, Portuguese East Africa and Southern Rhodesia. By 1953 no less than 97,000 acres had been planted and 47 million lb. tea produced in that year. The potential of Eastern Africa as a tea producer and exporter is enormous.

It is probable that a fourth phase in the industry is now taking shape in the U.S.S.R. where a total of 220,000 acres under tea is planned for the Five-Year period ending 1955. Why this may be considered a new phase is that tea plant types are being selected to suit the harsh climate of southern Russia, mechanical plucking will probably be employed, and the product is mainly for home consumption. The proposed development of tea culture in North Queensland may also be included in the fourth phase of development for here also, field mechanization will be essential and the product would be grown for consumption in Australia.

The East India Company

The merchants of the East India Company were primarily responsible for the development of the tea trade and of tea planting, which together comprise the tea industry.

In the year 1600 a charter was granted to 'The Governor and Company of Merchants of London trading into the East Indies' giving them the sole trading rights in all countries beyond the Cape of Good Hope and the Straits of Magellan for fifteen

years. In 1609 James I renewed the charter 'for ever'. In the reign of Charles II the charter was extended and the Company was given the right to acquire territory, coin money, command fortresses and troops, form alliances, make war or peace and exercise civil and criminal jurisdiction. It became what is now known as a Chartered Company.

In India the Company built factories at Surat in 1608, Madras in 1639, Bombay in 1668 and Calcutta in 1690. Much was done to develop trade in India and China. Reference to the struggle of the English Company with the Portuguese and the Dutch in the Far East has been made in the chapter on tea in China.

From about 1715 the East India Company, or John Company as it was often called, took complete control of the tea export trade from China and held it till 1833. During this period of monopoly, tea developed into a popular drink not only in England but also in the American colonies which were becoming populous and wealthy.

Between 1756 and 1763 England was engaged in the Seven Years' War with France and, being impoverished and to help pay for a standing army in America, sought to raise funds by the Stamp Act, passed in 1765 whereby stamps on legal documents in America were paid to the English Government. Other taxes were later imposed, to the indignation of the colonists. After protests, all taxes were removed except that on tea and this was to benefit the East India Company who had previously helped the Government financially.

In 1773 a ship in Boston Harbour was boarded by colonists and the tea thrown overboard as a mark of protest against taxation by England. This so-called Boston Tea Party led to the Battle of Bunkers Hill, the American Revolution and the Declaration of Independence in 1774. These events not only turned America away from tea to coffee, as a beverage, but no doubt profoundly affected the subsequent history of the world.

Meanwhile the Company had its trading monopoly renewed from time to time by the English Government, in spite of protests from other concerns who wished to trade in the East. However in 1813 an Act was passed ending the Company's monopoly of trade in India and in 1833 Earl Grey's Act ended

all trading privileges in China. This year marked a turning-point in the history of the tea industry. In due course, in 1855 the Indian Mutiny broke out and in 1858 the East India Company handed over its ruling functions in India to the British Government.

To return to trading in China tea, the Company were simply buyers, who knew little about where or how the tea was grown and prepared. It was collected by Chinese merchants in distant villages, sorted and re-fired at tea centres and eventually brought to Canton and sold in lots. The Company bought silk and tea but paid for these mainly in silver and bullion, because the Chinese needed little merchandise in exchange. Mention has already been made of the development, by the Company, of the opium trade between Calcutta and Canton as a means of balancing the China trade with something other than bullion.

Even as late as 1840 the coast-trade was carried out with the silver coin of many nations, rupees, dollars, shillings and Dutch coins, which passed current by weight. After the Opium War in 1840, which resulted in the opening of the Treaty Ports and the end of the Chinese policy of seclusion, a normal trade of exchange of goods was inaugurated.

The Tea Plantation Industry

The early interest shown in tea planting in Java and in Assam has been described elsewhere, as has the development of tea plantations in North-East India, Ceylon and Indonesia or the Netherlands East Indies. The spread of the tea industry to South India and Eastern Africa has also been dealt with. The mode of advancement in each country has been similar.

In Assam it was known about 1820 that tea was grown there by the hill tribes, but it was at the instigation of the East India Company that the matter was seriously taken up. On 10 January 1839 tea made in Assam was sold at the London auctions, and in that year the Bengal Tea Company was formed in Calcutta to purchase the East India Company's plantations in Assam. At the same time a company was formed in London with a similar object and almost immediately the two amalgamated to form the Assam Company in 1839. The modern tea industry then began, although it was only about 1860 that it was safely established.

The formation of limited liability companies, either to take over tea estates or to open up new ones in North-East India has proceeded in the normal manner of business. However, the Agency House system has also developed, whereby one Agency may look after the affairs of several companies dealing in such diverse operations as tea estates, jute mills, coal mines, shipping, insurance, &c. The Agency House was a necessity in the early days when communication between Calcutta and London was a difficult and lengthy process and a representative on the spot was essential, but although communications are now rapid and simple the Agency House has persisted. The system has been adversely criticized, but shortcomings when they do occur are not due to the system as such. An Agency House not only carries out the necessary business arrangements of an estate, but brings stability of policy, management, method and procedure. Most of the Agency Houses in Calcutta now managing tea estates have been established for 80 to 100 years, whilst the present oldest House was founded in 1819 a few years after the East India Company lost its trading monopoly in 1813.

A year of interest in the development of the plantation industry is 1888 when the China tea exports touched their peak at 300 million lb. of which 170 million lb. came to Britain. In the same year 90 million lb. were produced in India. In 1953 the Indian output touched 660 million lb. making that country undoubtedly the world's biggest tea producer.

Ceylon began to develop its tea industry about 1875 and advanced rapidly to produce a crop of 150 million lb. in 1901. In 1953 the outturn was over 340 million lb.

The industry in the Netherlands East Indies did not get seriously going till after 1900 but in 1939 the total production was 200 million lb. as against 250 million in Ceylon and 500 million lb. in India in the same year. Indonesia has not yet recovered from the war and the present outturn is under 100 million lb.

Up to 1930 there had been ordinary business competition and friendly rivalry amongst the major producing areas. Visits and ideas were freely exchanged, but in days of expansion there was no call for close co-operation between the producers. The serious fall in prices which began about 1928 and culminated in the slump of 1932 forced the three countries to put into action the

so-called International Tea Regulation Scheme in 1933. The International Tea Market Expansion Board followed as the next step in co-ordination within the tea planting industry.

Of recent years the Africa tea areas, which have in most cases been opened up by Agency Houses with interests in India and Ceylon, have joined with the other major producers in schemes of expansion and control. The two terms appear to be antagonistic, as indeed they are, but expansion is inevitable and control essential if slumps and booms in prices are to be minimized or avoided.

In this brief outline of the development of the tea planting industry nothing has been said of the small holder or village grower who sells leaf to a nearby factory. Small holdings are common in Java where they totalled 160,000 acres before the war, in Ceylon where they include nearly 70,000 acres, and to a small extent in the Nilgiris in South India.

It is common experience with practically all tropical crops when cultivated by peasants that the return per acre falls far below what is obtained when the same land is worked on estate scale. In Ceylon, experience has shown that when peasant proprietors have taken over productive and flourishing tea properties the standard of cultivation and level of production rapidly fall almost beyond belief. Quite apart from the fact that the expenditure per acre for field work, fertilizing and plucking is too high for the average smallholder to meet, the question of the time of plucking and the type of leaf taken is an important one. To run a big tea factory a steady supply of standard leaf is needed and this is only obtainable if the factory and field are under one management. Tea production is most efficient when in the hands of big companies.

Public Tea Auctions

Amsterdam is the oldest tea market in Europe. When the East India Company gained the monopoly of tea trading it held auctions at East India House prior to 1833. The sales took place four times a year in March, June, September and December and up to 8 million lb. tea was disposed of in one sale and as much as $1\frac{1}{4}$ million lb. in one day.

Much business in London in the eighteenth century was transacted in the coffee houses and to take their place the

London Commercial Sales Rooms were opened at 30 Mincing Lane in 1811. When the East India Company lost its monopoly of the China tea trade in 1833 it also lost its selling monopoly in London. Accordingly in 1834 the tea auctions were held in the Commercial Sales Rooms. The building was remodelled in 1896 and served as the public tea auction room till Plantation House, in Fenchurch Street and Mincing Lane, was opened in 1937. The procedure and conditions of sale at the tea auctions in London are practically the same today as they were when they were inaugurated.

Public auctions are also held in Calcutta and Colombo. In March 1947 tea auctions were started in Cochin to deal with South Indian tea, and in July 1949 Chittagong auctions were started for East Pakistan teas. Recently tea auctions have been opened in Djakarta.

The following table is of interest in that it shows how the newer auction centres are becoming established. There is no 1950 sales figure for London because the auctions there did not reopen after the war till 16 April 1951 when the Ministry of Food de-controlled the sale of tea in the United Kingdom. In 1933 the amount of tea sold at the London auctions was 447 million lb.

TEA SOLD AT AUCTION CENTRES
(amounts in million lb.)

<i>Year</i>	<i>London</i>	<i>Amsterdam</i>	<i>Calcutta</i>	<i>Colombo</i>	<i>Cochin</i>	<i>Chittagong</i>	<i>Djakarta</i>
1950	—	13	254	177	7	11	—
1951	109	14	291	215	20	16	—
1952	288	11	277	238	25	19	24
1953	317	9	256	258	33	22	18

Procedure in all the auction centres is similar to that in London. The London sales include teas from North and South India, Pakistan, Ceylon, Indonesia, Africa, Mauritius and Malaya whereas sales at the centres in the East include practically all locally grown teas.

In 1954 of the total sales in London amounting to 287 million lb. 163 million lb. came from North India, 28 million lb. from South India, 10 million lb. from Pakistan, 69 million lb. from Ceylon, and 15 million lb. from Africa. Apart from these amounts, teas from other producing countries were sold privately.

CHAPTER XVII

TEA TASTING

Taste and aroma—Tea tasting—Terms describing the appearance of the tea—The infused leaf—The liquor—General characteristics.

THE tea taster describes and values tea. His description of the liquor is based on taste which, in its widest sense, includes aroma, a very complex property that has so far not been assessed chemically.

Whilst the taster's description and evaluation are wholly satisfactory for trade purposes, in order to establish scientific control in tea manufacture it is essential to have more precise specifications of the characteristics which go to make a tea infusion. A scientist writing in London in 1879 on the chemical analysis of tea stated that the time was not far distant when the tea trade would buy entirely by analysis. Much more data of a chemical nature is available now than when that opinion was expressed but the time when analysis will replace the taster is as far off as ever.

A taster can deal with several hundred tea samples in a day and in making evaluations he brings his knowledge and experience of the outturn of the particular estate to bear upon his conclusion. He is therefore not likely to alter his evaluation unduly because a particular sample of tea is very good or very poor, although a chemical analysis of the sample might suggest a very high or very low value for the whole break from which the sample was drawn.

Taste and Aroma

When the tea taster takes the tea into his mouth with a loud sucking noise, the liquor is swilled round the tongue and gums and the aroma is drawn to the back of the mouth and up to the

olfactory nerve in the nose. The taster thereby tastes, feels and smells the liquid.

Taste is experienced mainly on the tongue and some other surfaces of the mouth. There are four kinds of taste, salt, sour, sweet and bitter. Sweetness is tasted about the tip of the tongue, and bitterness at the back. Saltiness is tasted at the tip and sides of the front of the tongue and sourness at the back edges. Astringency or pungency is a sensation, not a taste, and is felt on the gums and parts of the cheek. When the liquor is swilled round the mouth the thickness or body or viscosity is felt and judged.

As already indicated, the aroma of the liquor is detected by the olfactory nerve. Without the use of this nerve it is practically impossible to tell the difference between one article of food and another, for the main kinds of taste are similar on the tongue, whatever their origin. The complex aroma that goes with tea is distinct. Probably some part of the aroma is present in fresh leaf and the acrid smell of a field of tea persists in manufacture and forms part of what is called character. As indicated in Chapter V, dealing with the chemistry of tea, some tasters can smell quality or part of this asset on leaf in the field, which would indicate that one property which makes up the 'quality' of tea, using the term in its narrower, particular sense, is detected by the olfactory nerve and is present in the fresh leaf. The so-called flavour of tea is in part a flowery smell apparently produced during fermentation. Some of the aromas which occur in tea leaf and in tea are mentioned in Chapter V.

Tea Tasting

Tea tasting is a highly skilled accomplishment and one which only those with a good natural palate and a very active olfactory nerve can perform. Apart from tasting and describing a tea, the ability to value a tea calls for long experience and knowledge of the particular mark. Of a break of say thirty-six chests comprising about 40,000 lb. tea, a 1-lb. sample is drawn from one chest opened at the warehouse and from that small sample, weighing 454 gms. a 3-gm. weighment is infused by the taster. It is hence understandable that in evaluating a tea the reputation of the mark as well as the brew of a minute fraction of the break shall be taken into account. This point is further

appreciated when the simple method of bulking tea in a factory is remembered.

The taster's infusion is made from a quantity of tea equal in weight to a silver 6*d.* piece or a silver 4-anna piece (about $\frac{1}{10}$ oz., 3 gms. or 34 grains). The tea is placed in a mug of capacity about $\frac{1}{4}$ pint, fitted with a lid. Boiling water is poured on the tea, the lid replaced and the infusion allowed to stand for six minutes, after which the tea is decanted into a handleless cup of somewhat bigger capacity than the mug. The infused leaf is shaken from the mug on to the inverted lid which is placed in this way on top of the mug.

The infused leaf is called the infusion by the tea taster, whilst the infusion or the brew is called the liquor. When the taster comes to the table to a batch of samples or an invoice, he has before him in the back line a row of samples of dry leaf in tins which are labelled with the estate name, the invoice number, the grade and other details. In front of each dry leaf sample is the corresponding infusion on the inverted lid, standing on the mug. In front of the infusion is the corresponding liquor in the cup.

The dry leaf is described with relation to its colour or complexion, the amount of twist, the evenness of the grade, the general make and the amount and kind of tip, if any. The presence of stalk or dust is recorded. The leaf may be felt as a test of crispness and smelt by putting some in the hand, exhaling into it to warm and moisten it and then inhaling. All this takes only a few seconds; meanwhile the taster has read the name on the tin containing the tea and has subconsciously assembled his knowledge and experience of the outturn of the particular estate.

The infusion is next described with regard to its colour, evenness, brightness and perhaps its nose or aroma. If the infusion is smelt the mass of leaf may be heaped with the finger to make a place for the nostrils and to ease the passage of air through the wet leaf to the nose.

By this time the taster has a fair knowledge of what to expect from the brew. The optimum temperature for tasting a liquor is 106° to 110° F. The brightness and the colour of the liquor are noted and perhaps (subconsciously) the amount the light from the bottom of the cup is refracted by the liquor. A little

of the liquor is then sipped either from the cup or from a spoon and drawn into the mouth with a loud sucking noise, air is sent from the mouth through the nostrils, and the liquor thus smelt, after which it is spat into a tall spittoon. In this way the body or thickness of the liquor is felt, the pungency is experienced on the gums, a slight bitterness may be tasted at the back of the tongue and many aromas detected by the olfactory nerve. A volume of the liquor equal to about half a dessert spoon is used for tasting.

When the tea cools a precipitate or 'cream' is formed consisting mainly of a combination of caffeine and ethyl-acetate extractable condensed polyphenols. This cream is desirable and indicates quality in a liquor, using the term in its general sense. A taster knows whether a liquor will cream down or not without waiting for it to cool.

Tea is generally tasted without milk, but blenders add it. A good liquor gives a bright amber colour with milk perhaps with a little pink in it. In Chapter V it is described how the making of a good tea depends in getting a nice balance of the condensed polyphenols producing briskness, strength and colour of liquor. If a liquor gives a good colour with milk it is some guarantee that an acceptable compromise has been made between briskness, strength and colour. All three properties depend on the polyphenols in the leaf and an excess of one can only be made at the expense of the others.

Samples of every break of every invoice are sent to the brokers who sell the tea and these are described long before the tea reaches the auctions. Before the auctions the teas are again tasted and valued in accordance with market rates then holding. Teas are described within their own class, so it often happens that the description of an invoice from a poor quality estate reads much the same as that of one of good quality. This is understandable, for a taster assumes that an estate is making the best possible of the inherent properties of the leaf, and a tea is only condemned if some blemish is apparent.

A recent glossary compiled of tea taster's terms as commonly used to describe tea in India contained 116 expressions, many of which are redundant. Such a number is not necessary and only confuses the planter. There is a tendency now to report in a simple manner. The physical characteristics mentioned are

quantity of tip, colour of tip, appearance of dry leaf and appearance of infused leaf, and the liquoring characters described are quality, briskness, colour and strength. About twenty terms are sufficient to meet the requirements of most cases.

It is of interest to record that the liquoring qualities of coffee and of wines resemble those of tea and that tasters of these commodities use many of the same expressions as tea tasters. From what has been written earlier in this chapter on the subject of taste, this similarity is not unexpected.

In the next sections, the expressions used to describe various characteristics, both good and bad, are put down together with some explanation as to how the various blemishes may be caused.

Terms Describing the Appearance of the Tea

Brownish: Leaf brown in colour. Under-withered leaf fired at high temperatures produces brownish leaf, as does coarse leaf.

Blistered: Leaf swollen and hollow inside. Blisters are formed in the second firing of the leaf which has been too rapidly dried in the first fire and thereby case-hardened.

Black: Leaf black in colour. Fully withered leaf gives black tea.

Bloom or Complexion: A good bloom or complexion suggests that the varnish of dried tea juices which covers the leaf has not been cracked and rubbed unduly in sorting. Over-sorting spoils the bloom and also reduces the quality of the liquor.

Bold: Indicates that the pieces of leaf are big for the grade and should be smaller.

Choppy: Leaf has been broken in a breaker or cutter, rather than in the roller. Frequently noticed when tea leaf is cut to make broken grades.

Clean: Free from fibre and dust.

Crepy: Leaf crimped in appearance.

Even: Leaf true to grade and consisting of pieces of roughly equal size.

Flaky: Leaf not twisted, but in flakes. Results from hard rolling of under-withered leaf or manufacture of hard, coarse leaf.

- Grey*: Greyness results from too rapid firing, raising minute blisters on the leaf which are broken in sorting. Also results from too much sorting and cutting.
- Silver tip*: Grey in colour. Over-withered leaf gives grey tip which often accompanies black leaf.
- Stalk*: Indicates the presence of red stalk, resulting from coarse leaf and hard rolling.
- Uneven*: Irregular pieces, indicating bad sorting and overloaded machines.
- Well-twisted*: Fully withered leaf gives well-twisted tea.

Terms Describing the Infused Leaf

- Bright*: Bright red in colour, often denotes a good liquor and perhaps indicating the possibility of a good second brew.
- Coppery*: A bright copper colour is often given by quality teas.
- Dull*: Brownish in colour, suggesting a poor liquor. May result from poor leaf, over-withering, over-fermentation or too high temperature during wither and fermentation.
- Green*: Results from under-withering, under-fermentation or insufficient rolling. The liquors are usually raw or thin, according to the fineness or coarseness of the leaf.
- Mixed or Uneven*: The infused leaf contains red, black and green colours. Results from uneven withering, rolling or fermentation and from coarse leaf.

Terms Describing the Liquor

The tea infusion is referred to by the taster as the liquor.

- Brisk*: Having a 'live' characteristic. May indicate some degree of pungency and may be allied to quality. Is closely allied to the 'cream' precipitated on cooling.
- Bright*: Bright and clear in colour. The second flush Assam teas give brightness with an orange tinge, whilst later in the season the colours are rosy red.
- Body or Thickness*: A concentrated, bright red infusion which creams down well.
- Colour*: Denotes a good colour, bright red and clear. A liquor with colour will give a bright amber colour with milk.
- Dull*: Brownish liquors which are not bright and clear, giving a

greyish yellow colour with milk. Such teas are over-fermented, fermented at too high temperatures or are made from poor leaf.

Flat or Soft: Lacking in briskness and strength. Over-fermented.

Fruity: Suggests a taint due to bacterial infection which probably occurs on the fermenting space.

Full, Mature, Rich, Ripe, Round, Smooth: Terms denoting a liquor with strength but little briskness. Suggests full fermentation.

Hard, Harsh, Raw, Rasping: Terms denoting a liquor with marked pungency and bitterness but with little strength. Suggests under-fermentation.

Light: An infusion lacking body and briskness. Probably due to inherent poorness of the leaf.

Pungent: Having astringency without bitterness.

Strength: A combination of thick liquors with pungency.

Sweet: A light liquor that is not necessarily undesirable.

Thick: A concentrated bright red infusion that creams down well.

Thin, Weak, Washy: A dilute infusion of little value, usually resulting from inherently poor leaf.

Terms Describing General Characteristics

Aroma: Denotes that the infusion and the liquor have one of a number of smells in a concentrated form. Flavour is an aroma.

Bakey: A slightly high-fired tea.

Burnt: A taste and smell of burnt organic matter. Denotes too high firing temperature in a single fire, or in the second dryer of a double fire.

Coarse: Aliquor deficient in tea aromas. Results from coarse leaf.

Cream: The precipitate that forms when tea cools. Denotes briskness and strength, which may be included in the general term, quality.

Dry: A characteristic of a liquor given by tea which has been kept overlong in the dryer after it is fully fired.

Flavoury: Denotes a sweet flavoury smell together with the acrid smell of tea. Marked flavour is seasonal, often associated with spring growth or slow growth in the autumn or dry season.

Gone-off: A mouldy or tainted tea, a flat or old tea. Often denotes a tea packed with too much moisture and infected with moulds.

Hay flavour: A characteristic which often precedes autumn flavour.

High-fired: A high-fired tea but not burnt. Results from keeping the tea in the dryer at 200° F. or more after it is fully fired.

Malty: A desirable quality. May be due to slight high-firing or to a bacterial infection.

Mushy: A soft tea, suggesting it has been packed too moist.

Nose: Indicating aroma.

Plain: Lacking in tea characteristics and aroma. Suggests coarse leaf.

Point: Some desirable characteristic, possible briskness.

Quality: This term is used in a general sense to denote desirability or in a special sense to denote a special blend of characteristics which may include both taste and aroma. Quality, in its special sense, is inherent in the leaf and is present at some periods of the season and markedly in some types of bush.

Smoky or Tarry: Tastes of smoke. May be due to leaky stove tubes which allow smoke into the drying chamber. In some China teas a tarry or smoky flavour is valued.

Stewed: A dull tea with a taste reminiscent of stew. Often results from faulty first firing with too low an exhaust temperature.

Sweaty: Tastes like sweat smells. May result from over-fermentation on a bacterially infected fermenting space.

Tainted: A tea having a strange aroma. May result from bacterial infection or from contact with a foreign body, e.g. oranges, onions, kerosene.

Weedy: A faint grassy or hay aroma which is undesirable.

CHAPTER XVIII

THE MARKETING OF TEA

The tea markets of the world—Government examination of tea in the United Kingdom—The London tea sales—Tea blending—The distribution of tea—The advertising of tea.

As with the disposal of any commodity, there are two sides to the marketing of tea. First there is the disposal in bulk by the producers either in the country of origin or in one of the world markets. The purchaser then blends, packets and distributes the tea. In some cases the distributor also owns tea estates, which are generally run as separate companies, but even then it is preferred to sell the product of the estate on the open market for in this way the tea fetches its true value in competition with other teas of its class.

The Tea Markets of the World

There are tea markets in all countries where the commodity is produced on a large scale. Before the war the greatest mart in China was Hankow where the teas of the Yang-tsi Valley were collected, sorted and sold. Hankow was also the centre of the Russian brick tea mart, whilst Ya-chow in Sze-chuan was the centre of the brick trade with Tibet and Mongolia. Of later years the importance of Shanghai as a tea centre increased.

Just where the China tea trade is centred at present is not clear. In 1949 the Ministry of Commerce set up the China National Tea Corporation which apparently controls the export trade and handles 80 per cent of the total trade. The tea is presumably collected from village centres, then processed and packed in Government factories.

The Formosa tea trade is centred at Taikoku, and the Japan trade at Shizuoka, at which places European buyers are established.

Mention has already been made of the markets in Calcutta,

Colombo, Cochin, Chittagong and Djakarta where tea auctions are held. Apart from these regular centres of sale there are tea marts in many places, for example, at Kyaukse in Burma, where pickled tea is sold, at Amritsar in North India, where tea from Dehra Dun and the Kangra Valley is dealt with. In South India there are dealers in Trichinopoly and other centres.

The markets outside the tea-growing countries are Amsterdam and London, the latter still being the largest in the world although those of Calcutta and Colombo are comparable in the amount but not in the variety of the commodity sold. The section dealing with public tea auctions in Chapter XVI gives statistics relating to the size and nature of the London market compared with others.

As part of the description of the way in which tea is dealt with in the United Kingdom, the examination by the Customs Authorities is first detailed, followed by a brief account of the tea sales and the blending, distribution and advertising of the product.

Government Examination of Tea in the United Kingdom

According to the Customs and Excise Act of 1952, Section 229, all tea entering the United Kingdom shall be subject to examination by persons appointed by the Commissioners of Customs. If samples are mixed with foreign substances or exhausted leaf the tea shall not be delivered in the United Kingdom. If in the opinion of the Government analyst the tea is unfit for human consumption it shall be destroyed or forfeited.

Teas are examined in the warehouses by Government examiners and if there is any doubt the samples are sent to the Government Laboratories of the Customs Department in the City of London. Here about 5,000 samples are examined yearly of which less than 100 are rejected. The faults are usually due to mouldiness or the presence of foreign substances and sweepings.

There are no definite specification tests for tea laid down by the authorities and the decision regarding unfitness rests with the analyst. The tea is first infused in the manner followed by the tea taster and the infused leaf examined for colour and smell. A tea is usually bad because it is mouldy and the infused leaf of such tea is often black. The presence of foreign leaves is

detected by hand lens and confirmed if necessary by microscope. The presence of exhausted leaf may be judged by the total ash and soluble ash in the leaf. The former should be 5.5 to 6 per cent and the latter 4 per cent of the dry matter. Of the total ash all but 1 per cent should be soluble in dilute acid and a much greater figure than this indicates the presence of impurities, like sand.

According to the Food Standards Committee of the Ministry of Food the amount of lead allowed in tea entering the U.K. is 10 parts per million. The figure in the U.S.A. is only 2 p.p.m. and about twenty years ago considerable agitation was caused in the tea industry by the fact that some samples contained up to 5 p.p.m. Accordingly the packing of tea in lead foil was abandoned and aluminium foil used in its place.

The tolerance for copper is only 2 p.p.m. for beverages other than wines, beers and cider, but the figure for dry tea has been limited provisionally at 150 p.p.m. on account of the use of copper fungicides in Ceylon and South India against Blister blight.

Tea which is rejected by the Government examiner is denatured with lime and usually sold for caffeine extraction. Caffeine is used medicinally and in some soft drinks.

The London Tea Sales

Tea is despatched by the estate manager to the local port where the managing agents of the estate consign it to the representatives of their firm in London. An invoice of tea is sent at a time and may include anything from sixty to 240 chests, more or less. The invoice should consist of tea made over a short period and in Assam during the four busy months, two invoices a week may be despatched from the factory.

With normal sorting an invoice comprises four to six grades. A grade is called a break and consists preferably of a number of chests which is a multiple of six. The average weight of tea in a chest is 110 lb. less for leaf grades, more for Fannings.

When the consignment reaches the London docks it is put into bonded warehouse (assuming there is a duty on tea) and is in due course put up for public auction by selling brokers.

The selling brokers draw samples from each break and examine them and issue catalogues in which the garden mark,

number and kind of packages, weight and grade of tea are described. The buyers also draw samples which they taste and evaluate, and by the day of the sale both buyers and sellers have formed their ideas of the value of the tea. The stock situation, market demand, prospects of future cropping in the growing countries and so on, are so well known to both sides, and tea tasting has become such an exact art, that the respective valuations are generally the same or very close.

The selling broker usually has the order to get the best possible price for the tea without reserve, but if a lot is withdrawn he (the selling broker) endeavours to dispose of it later to the highest bidder at the auction, by private treaty. The latter usually meets the seller at a price between his bid and the broker's valuation.

Selling brokers also do business on behalf of purchasers whose orders they have received before the auction. The sellers have 'market men' who appear in the box with the selling broker and bid as other buyers dealing in the room. Business of this type is often done on behalf of smaller buyers dealing with the Continent.

It might be thought that the 'market man' would be unable to work in this dual capacity without prejudice to the interests of either seller or buyer, but the necessity to retain the confidence of both sets of clients and the fact that the general current value of ordinary teas (excluding flavoured and exceptional parcels) is well known, ensures that the arrangement acts fairly to all parties.

The immediate purchasers at the tea auction are the buying brokers who re-sell later to dealers, blenders and merchants. Although the auctions are public and nominally anyone can bid, actually all purchases are made through buying brokers or the 'market man' of the selling brokers. The buying broker often buys teas for which he possesses no order and these are placed on the 'bought over' list which is issued daily, and from this list dealers, blenders and other distributors can select the teas they require. In this way a small dealer can obtain the teas he needs in quantities too small to be dealt with at the auction.

It might be thought that the buying broker is an unnecessary link in the chain of distribution and that his intervention merely increases the cost of the tea by the amount of his commission.

However, his existence enables the small buyer to purchase from the 'bought over' list and also acts as a cover to the nature and magnitude of the purchases of the bigger buyers. Although the large distributors attend the auction they do not actually bid.

The Tea Brokers' Association in London issues a weekly Tea Market Report which gives the price of every invoice sold, together with the tea stock position and many other details relevant to the market.

The Blending of Tea

Tea blends are made to suit the water, which is chalky or hard as in eastern England, or soft as in much of the rest of Great Britain. Teas are blended in revolving drums, and they are weighed, packed and labelled by elaborate machinery.

Several characteristics go to make up a good tea, some of which are flavour or aroma, quality, briskness, strength and body. Since a tea may be richly endowed in one quality and lacking in another it follows that the task of the blender is to produce a mixture which will give a nice balance of all the desirable properties. Practically no unblended tea reaches the consumer and a blend may contain the teas from twenty different estates.

The blending is done by a tea taster and since the product of every estate is always changing, it follows that if the blend is to remain constant a diverse collection of marks must be employed. When the price of quality and flavoury teas rises too far, the price of the blend is kept steady by using a greater proportion of cheap tea, known as the 'filler'. But there is a limit beyond which 'fillers' cannot be carried, otherwise the liquoring qualities suffer appreciably and the sale of the blend goes down.

In blending for some markets, particular attention must be paid to the appearance of the tea. For example, parts of Ireland take tippy teas, which is logical since tip denotes pubescence of the leaf, which in turn denotes quality, and quality teas are certainly better value for money than poor teas. The United States and the Continent often prefer leaf teas, although this demand is slackening, as it usually does when people become habitual tea drinkers, and broken grades giving more colour and strength are now in demand in both these markets.

The Distribution of Tea

Some years ago it was common for the dealer to supply the original chests to the distributor or retailer who made his own blends. Today it is usual for the dealer to be replaced by the blender who blends tea wholesale and distributes it in packets. The great bulk of the packet tea thus sold is a proprietary article and ensures a steady blend of fresh tea. In this way the grocer becomes a middle-man with no personal interest in the tea he sells, as he would have if he had constructed the blend himself. This tendency is by no means confined to the selling of tea. Apart from this however, the public is much better served by using a blend made up by specialists with a whole range of teas to choose from.

If a grocer wishes to build up a business of non-proprietary blends, he is catered for by certain big blenders who distribute a parallel range of teas known as grocers' blends. The grocer chooses his own blends from several samples submitted and thereby is able to exercise his own personal judgement.

The Advertising of Tea

Most of the spread of the tea habit in Great Britain has been due to the advertising of the tea dealers. Incredible as it seems today, the expression 'given away with a pound of tea' is a relic of the early efforts of dealers in this country to push the sale of the commodity.

The planting industry has also taken a hand in pressing sales and as early as 1879, even before the Indian Tea Association was formed in 1881, the Agency Houses in Calcutta formed a syndicate whose object was to find fresh markets for tea. Tea was displayed at the Sydney Exhibition by this syndicate, then at Melbourne and later attention was paid to Canada and America. In 1889 tea was displayed and sold at the Paris Exhibition.

In 1893 a voluntary levy was raised by the Indian Tea Association and in 1903 the Tea Cess Act was passed. From this was evolved the Tea Market Expansion Board and in due course the International body comprised of the industries of India, Ceylon, Netherlands East Indies and various African areas. The success of these Boards in expanding tea sales has been remarkable.

CHAPTER XIX

THE PRODUCTION, EXPORT AND CONSUMPTION OF TEA

Slumps and booms—The International Tea Regulation Scheme—Production and export—Consumption.

IN dealing with the question of world production and consumption of tea, the subject of booms and slumps in prices naturally arises for consideration, together with the problem of the control of such irregularities.

Slumps and Booms

As with trading in other commodities, that in tea has suffered from time to time the disorganization of slumps and booms in prices. The demand for tea has been generally expanding since it became an article of export from producing countries, but it is difficult to equate supply and demand to a nicety, especially since a deficit or excess of requirements of 20 million lb. may be sufficient to affect prices even in present times, when the total exports from the principal countries range from 900 to 1,000 million lb. per annum.

One difficulty in balancing outturn with demand arises from the fact that a new area of tea takes about seven years to mature, so that extensions must be planted with a view to meeting market requirements several years hence. Another factor which tends towards price instability is the stock position. Tea cannot be stock-piled for more than a few months because, quite apart from the expense of carrying heavy stocks, the commodity is liable to go-off if kept too long. In Britain it is reckoned that a reserve of six months' stock is ample for market requirements.

In China when export demand slackens, presumably the villager, not wholly dependent on selling the tea he does not want for his own use, just carries on with a little less ready money

to handle. With a plantation however, a slump in prices is a much more serious matter, for it connotes a reduction in cultivation and fertilizers and a curtailment in expenditure on buildings and equipment. During the 1920 slump in Assam many extensions were ruined by thatch grass, whilst it took up to three years to clear other areas which had become thatch-ridden during the lean period.

The first slump in Assam was experienced in 1866, when the industry there was barely twenty-five years old and the effects of too rapid opening became apparent. In 1865 India exported $2\frac{3}{4}$ million lb. tea whilst in 1866 the figure was nearly $6\frac{1}{4}$ million lb. and the price fell from 1s. 11d. to 1s. 1d. per lb. Prices rose again the next year and remained at about 1s. 9d. for the following ten years during which exports steadily increased to about 25 million lb. per annum.

The second slump came in 1879, following on a boom in prices brought about by the rumour that China exports might be 20 million lb. short. At this time the exports from China and Japan totalled 160 million lb. and from India 40 million lb. This slump included other colonial products as well as tea, but by 1881 conditions were on the up-grade again.

The third slump extended over the years 1896 to 1904 following the extensive opening up of new areas all over North-East India. By 1901 India had 524,000 acres under tea producing over 200 million lb. Ceylon had 406,000 acres planted producing 144 million lb. whilst the export of green and black tea from China was about 150 million lb. Field and factory procedure in the plantations was being modernized and in this way low prices were partly met by reduced costs. In 1905 prices began to improve and the industry enjoyed a degree of prosperity till the end of World War I.

The fourth slump was in 1920, after the British Government released for sale stocks held during the war. To meet this upset in the trade balance the industry in Assam, through the Indian Tea Association, agreed to stop plucking on 15 November 1920 in order to reduce outturn. In 1921 a poor season naturally restricted crop and the slump passed.

Then followed a few years of prosperity, good prices, extensions of planting and increase in outturn. During this spell estates were modernized and new machinery installed. Prices

continued to rise till 1927 then a decline set in which continued till 1931 when tea, in common with other commodities, slumped still further. In 1930 the tea growers in India, Ceylon and the Netherlands East Indies agreed to restrict their combined exports by $57\frac{1}{2}$ million lb. but this was only partially successful, owing to an unexpected reduction of tea consumption within India and the inability to control exports of tea from Java by Chinese merchants. Stocks in the United Kingdom rose to 270 million lb. in 1931 and to 309 million lb. in 1932, about eight months' supply. During 1932 the average price of common Assam tea on the London market was just over 6d. per lb. It is always the common teas which show the first signs of a fall in prices whilst the finest teas sell reasonably well through a slump.

This, the fifth slump, brought about a closer degree of integration between the three major producers than had been previously attained, which in due course made the International Tea Regulation Scheme possible.

The International Tea Regulation Scheme

Many observers had predicted the slump in 1930 some years before it became serious, for planting and production were rapidly outstripping demand. During 1932 the three big producers worked out a plan to regulate exports and to control the opening up of new areas, and the International Tea Regulation Scheme, administered by the International Tea Committee with the approval of the governments of the respective countries, was inaugurated in April 1933 to last for five years. A second Agreement from April 1938 was entered into for a further period of five years extended later to 1948. The tea areas in Eastern Africa and Malaya also participated in the Scheme for part of the time. Later agreements carried on till 1955.

In the original agreement the Standard Export in the three producing countries, India, Ceylon and the Netherlands East Indies, was based on the exports in any of the three years 1929, 1930 or 1931 and in the first year of regulation, 1933 the allowable export was fixed at 85 per cent of the Standard. This action was reckoned to reduce exports by about 100 million lb. compared with the Standard.

Under the terms of the Agreement, new extensions of planted

areas are limited to 5 per cent of the permissible acreage, whilst the replanting of up to 10 per cent of that acreage is allowed. The following table shows the Standard Export and Permissible Acreage in the countries concerned. Since 1933 there has been little change in the planted areas in India and Ceylon.

	<i>Standard Export million lb.</i>	<i>Permissible Acreage</i>
India . .	348	807,000
Pakistan .	35	80,000
Ceylon .	252	588,000
Indonesia .	174	540,000
Totals	809 million lb.	2,015,000 acres

The Scheme worked satisfactorily from 1933 onwards and each year the percentage of the Standard crop allowed for export was reconsidered with regard to ruling prices and demand. Between 1933 and 1939 there was a period of stability and prosperity for the industry during which machinery and equipment were renewed and much old and unthrifty tea was uprooted and replanted. This last was fortunate in that it put India and Ceylon in a position to meet extra demands for the commodity when the Netherlands East Indies were overrun in 1942 and ceased to export tea.

At the outbreak of war in 1939 the United Kingdom Government took over all stocks of tea in the country and requisitioned all tea due to arrive. On 24 August 1939 the tea auctions ceased in London and by the Tea (Control) Order, 1939 dated 5 September tea distribution came under the Ministry of Food. Tea was rationed, and purchased by the Government direct from the growers at a fixed, agreed price based on pre-war averages. The existing channels of distribution were still made use of.

By the end of 1940 the export trade from London stopped and outside markets secured their teas direct from the countries of production. In September 1942 the Ministry of Food, acting under the Combined Food Board in Washington, became the sole purchaser of tea for the United Kingdom and allied countries as well as for certain neutral countries. Thus the auctions

in Calcutta and Colombo ceased except for teas for internal requirements. This scheme continued till 1947 in which year the Calcutta and Colombo auctions reopened. The Amsterdam auctions reopened at the end of 1948 whilst Cochin and Chittagong became new tea auction centres in 1947 and 1949 respectively.

Meanwhile the Export quota had been 130 to 135 per cent of the Standard since the early years of the war, a figure that allowed India and Ceylon to make up for the deficit from Indonesia which even now is unable to muster more than 100 million lb. for export.

The post-war trade in tea was still affected by the continuance of the Government price subsidy and rationing in the United Kingdom, and even when the auctions in London were resumed on April 16th, 1951 these disturbing elements were in effect, although they were soon abolished.

As the 1952 crop from India came forward to the London sales prices weakened and most of the commoner tea sold at a serious loss. The average price for Indian tea fell from 3s. 8d. in 1951 to 3s. in 1952. Thus the tea industry experienced its sixth slump since the first in 1866 eighty-six years ago. Many Companies in India made serious losses over this crop.

In 1953 prices were satisfactory again. When the 1954 crop began to arrive at the London auctions in July, prices rose sharply and the rise continued till the week ending 20 January 1955 when the average for all teas sold was a record of 7s. 1.29d. per lb. Thereafter prices fell steadily and by the end of May the average was back to just over 3s.

These market vagaries have left the industry bewildered, for they have occurred in spite of the International Tea Regulation Scheme and in the face of a mass of statistics relating to stocks and crop potentialities.

Production and Export

In the chapters and sections dealing with individual tea countries, details of acreages and production have already been given. In the table below, figures for 1939 and 1952 are summarised in order that a normal year, 1939 may be compared with a recent year when the stresses of the War period are still in evidence.

AREA, PRODUCTION AND EXPORT OF TEA, 1939 AND 1952

<i>Country</i>	<i>Acreage</i>		<i>Production</i>		<i>Export</i>	
	1939	1952	1939 <i>million lb.</i>	1952	1939 <i>million lb.</i>	1952
China .	—	—	—	—	50	24
Formosa .	100,000	100,000	29	26	26	25
Japan .	98,965	74,029	127	101	52	19
India .	840,004	861,054	466	667	332	434
Ceylon .	553,845	572,008	237	316	228	314
Indonesia.	529,894	200,000	184	82	162	70
Africa	47,022	94,811	25	46	23	36
Malaya .	7,043	8,700	1½	3¼	¾	2¼

During 1939 a total of 880 million lb. tea was exported by the producing countries whilst in 1952 the total was about 910 million lb. of which India and Ceylon exports comprised 748 million lb. The 1952 production total, excluding China, was 1,242 million lb. the difference between production and exports, viz. 362 million lb. being consumed within the countries of production.

The China figures for acreage and production are not available and this is partly understandable because tea is a village industry. Tea for sale and export in China is now a Government monopoly and in 1952 the Government factories processed 182 million lb. tea. The bulk of the tea exported apparently goes to the U.S.S.R. whence some reaches the Soviet-bloc countries in Eastern Europe.

The export from Formosa and Japan is mainly green tea at present, which is taken largely by America and Northern Africa.

No mention of tea production in the U.S.S.R. is made in the table, because figures are not available neither does this country enter the world tea market with its product. However in 1936 the area under tea was reported as 96,000 acres by the International Institute of Agriculture, rising to 131,000 acres in 1940 whilst production in the former year was 11 million lb. rising to 28 million lb. in the latter. It is apparent that the U.S.S.R. may go a long way toward satisfying internal

demands for tea. The target area planned for 1955 is 220,000 acres and the production 40 million lb.

Before leaving the subject of production and export, some mention may be made of the difference between the two figures, representing consumption within the countries where the commodity is grown. What is consumed within China is not known and the figures given are largely guesswork. It is said that the Chinese take about 2 lb. per head per annum assuming that it is available. In this case the internal consumption might have been 1,000 million lb. before the countryside was laid waste by war and revolution, although the more conservative figure of 500 to 600 million lb. which is sometimes made is probably nearer the correct one.

Consumption in Formosa is small, of the order 1 to 6 million lb. but that in Japan ranges from 60 to 120 million lb. per annum. These figures allow for a very small consumption per head of the population either in Formosa or Japan.

In India, the Tea Cess Committee has been pressing tea sales for many years. In 1919 it was estimated that India consumed 30 million lb. tea, whilst in 1929 the figure had risen to 57 million lb. In 1939 it was about 100 million lb. and at present it is between 160 and 200 million lb. These quantities are computed from production and exports, and ignore changes in stocks at the ports or in the country. It can be concluded that India follows Britain as the next largest consumer of plantation tea.

Ceylon consumes about 15 million lb. tea. The tea producing countries of Kenya, Tanganyika, Uganda, Nyasaland and Southern Rhodesia take about 10 million lb. per annum.

The Consumption of Tea

Tea consumption in Britain averages about $9\frac{1}{2}$ lb. per head of the population. Of a total of about 960 million lb. tea exported for consumption to all countries of the world in 1952, no less than 490 million, just over half, were consumed in the United Kingdom and Ireland.

The table below shows the amounts of tea imported into each of the six continents during 1952 together with the quantity taken by the chief consumers in each.

IMPORT OF TEA, 1952

<i>Continent and Country</i>	<i>Import in million lb.</i>
<i>Europe: Total, 533 million lb.</i>	
United Kingdom	473
Ireland (Republic)	17
Netherlands	16
Western Germany	6
Others	21
<i>North America: Total, 140 million lb.</i>	
United States	93
Canada	45
Others	2
<i>Latin America: Total, 18½ million lb.</i>	
Chili	11
Argentina	5
Others	2½
<i>Asia: Total, 67 million lb.</i>	
Iraq	19
Arabia	16
Iran	6
Turkey	5
Malaya	6
Others	15
<i>Africa: Total, 133 million lb.</i>	
Egypt and Sudan	53
Morocco, Algeria, Tunisia	41
Union of South Africa	24
Others	15
<i>Australasia: Total, 64 million lb.</i>	
Australia	53
New Zealand	10
Others	1

The above table does not include any of the producing countries except Iran, Turkey and Malaya. When it is considered that in addition to the countries listed above, the peoples of the U.S.S.R., China, Japan, South-East Asia, Indonesia, India and Ceylon are considerable tea drinkers, it may be concluded that the only extensive areas in the world where tea has not yet gained a substantial market are parts of Western Europe and Latin America.

Finally it is of interest to tabulate certain tea drinking countries in order of their per capita consumption during the year 1953.

ESTIMATED PER CAPITA CONSUMPTION OF TEA IN LB.

<i>Country</i>	<i>Consumption</i>
United Kingdom . . .	9·4
Irish Republic . . .	8·7
New Zealand . . .	7·1
Australia . . .	6·5
Morocco . . .	3·6
Canada . . .	3·1
Egypt . . .	2·0
Netherlands . . .	1·8
Ceylon . . .	1·2
United States . . .	0·7
India . . .	0·5
Pakistan . . .	0·4

CHAPTER XX

CONCLUSIONS

IT now remains to draw some general conclusions with regard to the culture and marketing of tea. At the end of the first edition of this book, published in 1933, when an extended slump was ending with the inauguration of the International Tea Regulation Scheme, a long period of prosperity and stability for the industry was predicted. Since then, World War II and subsequent political upheavals have changed the outlook on the production side, whilst advances in the scientific study of tea growing and manufacture have considerably modified our views on field and factory procedure. Taking all these changes into account, coupled with further experience and observation in many tea countries over the past twenty years, the author's conclusions on certain aspects of the subject are summarized below.

1. Of the present countries growing tea on a large scale, the Assam Valley is the best equipped by nature with regard to climate, lie of land and soil. Enormous crops of quality tea can be produced with the minimum of effort and there are large areas of land suitable for extensions. The Assam Valley is the country *par excellence* for tea planting. The same holds to a somewhat less extent for other tea districts of North-East India.

2. The field methods now advocated in Assam and followed in the best Assam tea estates are fundamentally sound and should be tried in other tea countries. Modifications may well be needed, but Assam procedure should be taken as the base-line from which to start.

3. Experiments in Assam have shown the highly beneficial effect on certain types of tea of the shade canopy given by leguminous trees. The most profitable way to grow tea is under leguminous shade. Such procedure avoids the complications which may arise from the continued use of artificial fertilizers and postpones the period of soil exhaustion.

4. The botanical study of the tea plant, the development of vegetative propagation, together with the production of clonal seed, comprise the most important advance in tea growing since the China bush was replaced by the large-leaved types. The use of selected plants can increase both crop and quality far beyond the best obtainable from the present stand of tea.

5. Factory experiments carried out in Assam, Ceylon and Java over the past 60 years have shown, and intensive scientific study of the biochemistry of tea manufacture over the past thirty years has confirmed the fact, that to make ordinary tea, orthodox methods must be followed. Variations between certain times, temperatures, speeds and concentrations are allowable, because the small changes thus involved are not taken count of by the tea taster. Beyond these limits of variation a different tea is produced and such difference is penalised by the buyer, especially on a weak market.

6. Mechanization was introduced into tea manufacture 70 years ago with the roller and the dryer, and there can be little further labour saving at present in the factory. Field work has not been mechanized and until plucking is carried out mechanically there is not much object in dealing with the other operations in this way. The machine plucking of tea presents many difficulties. In Japan, fifty years ago the problem was solved by using plucking shears. Any kind of mechanical plucking involves the taking of uneven leaf but if this is accepted and the plucking round lengthened, enormous crops can be made with a much smaller labour force than is necessary with hand plucking.

7. Tea estates are best developed by large companies and most efficiently managed in groups, with individual units of 500 to 1,000 acres serving a factory. The system whereby small holders sell leaf to a central factory is not as efficient, either from the point of view of crop or quality, as plantation practice.

8. That the supply of and demand for the commodity shall be roughly equated, and the disturbing effects of slumps and booms reduced or avoided, some international scheme of control both of export and planting is necessary.

9. Exports of China tea are not likely to dominate world markets again. Whether the pressure of population on the land in Asian tea countries will allow a crop like tea to be grown

extensively for export remains to be seen. The countries in Eastern Africa have a potential and an opportunity to become one of the main sources of tea for export. The U.S.S.R. will probably develop its tea areas to meet home demands and will accomplish this by selecting a type of bush to suit the difficult climate in Georgia. The labour problem there will be solved by mechanical plucking. As a result of either or both of these innovations, many areas now incapable of producing tea economically will be enabled to do so.

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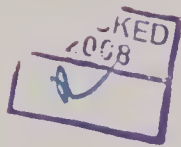
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